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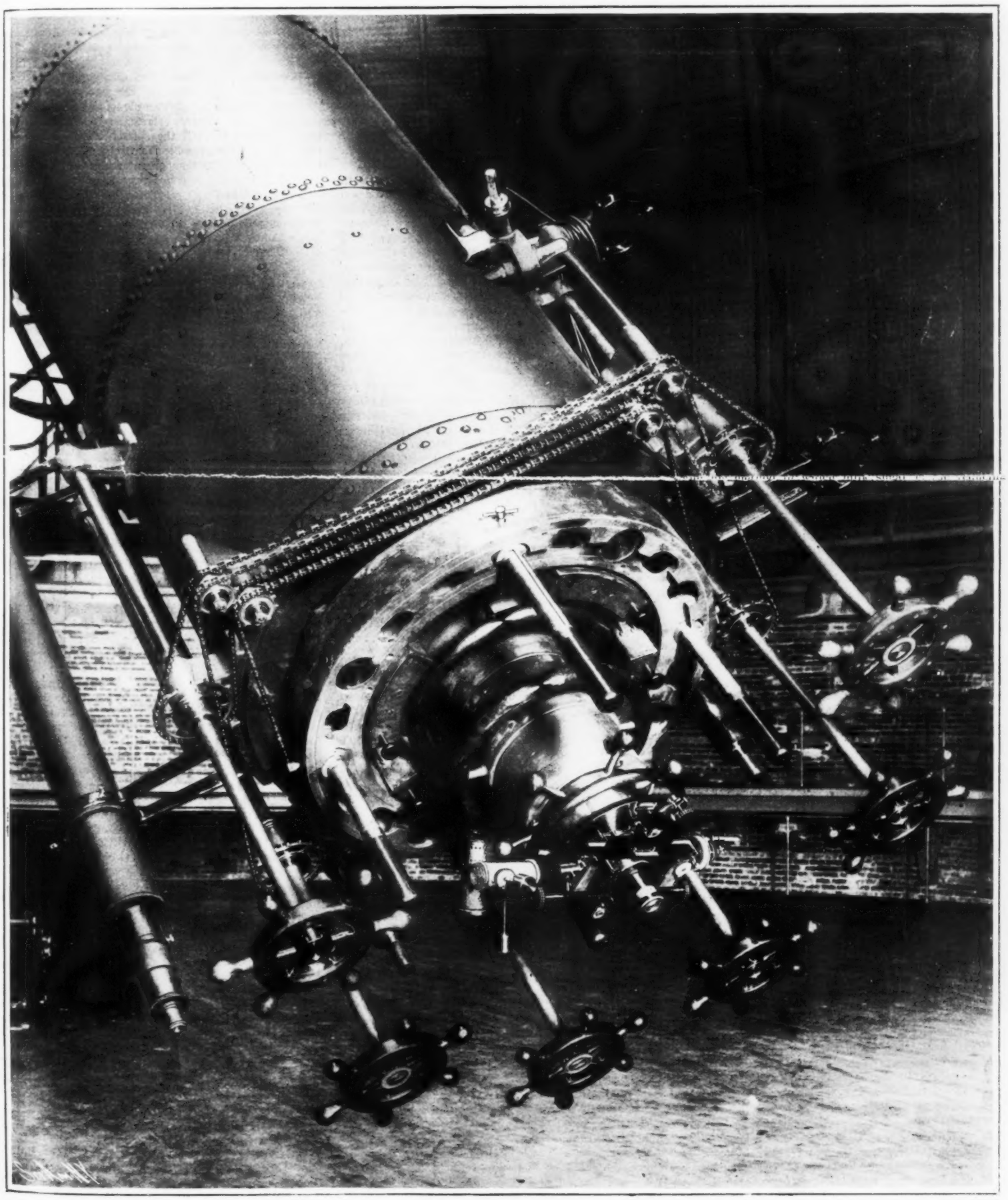


THE EYEPIECE OF THE GREAT FORTY-INCH TELESCOPE OF YERKES OBSERVATORY.

RECENT PROGRESS IN ASTRONOMY.—[SEE PAGE 200.]

TURPENTINE FROM WASTE WOOD.*

A LINE OF INDUSTRY WHICH HAS PROVED BAFFLING TO INVENTORS.

BY J. E. TEEPLE, PH.D.

THE name turpentine is stated to be of Persian origin and was probably first applied to the resinous exudation from some member of the sumac family. It is now confined to the resinous exudation of the conifer family, more particularly those of the genus *Pinus*, the pine proper. During recent years, efforts have been made by interested parties, and particularly by some of the State Legislatures, notably those of Georgia and New York, to restrict the name turpentine and oil (spirit) of turpentine to the resins and their distillates coming from the live tree as opposed to distillates of resins from waste wood. But this attempt has not met with general approval.

What may be called the old process oil of turpentine, or gum spirits of turpentine, is derived mainly from southwestern France, northwestern Russia, and southern United States. In the United States the most productive tree is *Pinus palustris*, or long leaf pine, although the Cuban loblolly pine, and in many cases, even the short leaf pine give paying yields. In France, the *Pinus maritima*, and in Russia, the *Pinus sylvestris* are the trees most commonly worked. The well known procedure in the United States is to prepare the tree by "boxing," i. e., cutting a receptacle in the base, and "facing" or preparing this receptacle for the gum. Then every week throughout the turpentine season, during the summer months, the tree is subjected to the hacking process, which consists in inflicting a fresh wound by cutting off a narrow section of the bark and outer sap wood of the tree. This process of wounding the tree has two effects. First, there is an exudation of the normal sap of the tree which might be compared to bleeding when an animal is wounded; and second, there is a pathological production of resinous material in the neighborhood of the wound which might be compared to the formation of a scab. This latter material probably makes up the greater part of the flow of gum, and to keep the process in operation it is necessary to re-wound the tree every week. As the resinous material flows out from the tree into the boxes, it is dipped at intervals of about three weeks, and conveyed to stills where distillation with water or steam drives off the spirit of turpentine, amounting to approximately 20 per cent of the total, and leaves the non-volatile material, which after drying and filtering, becomes the rosin of commerce. The yield from any tree depends on the season, weather, vitality of the tree, expanse of tree top, etc., and as the vitality is certainly decreased by the system of boxing, the cup and gutter system which obviates boxing has been coming into more extensive use within the last few years. This is a modification of a system that has been in use in France for over forty years. The greater part of the resinous material from the tree may be looked upon as a pathological product resulting from the wound, and not a normal product of the tree. Wounding a tree causes the formation of quite a large number of rosin ducts in the neighborhood of the wound, which gradually become stopped up with resinous exudation, so that when a tree has been worked for several years, the whole body of the tree up to a height of 10 to 15 feet, or at least as high as it has been chipped, becomes thoroughly saturated with this resinous material, which apparently does not differ in any appreciable degree from the resinous material that has been collected in the boxes, excepting that it contains a smaller percentage of spirit of turpentine and a larger percentage of rosin. This wood saturated with the resinous product from the tree is known as "light wood," and when we consider the rapidity with which turpentine orchards are disappearing, it is obvious that we must look to light wood as the future source of turpentine. When a tree is blown down by any of the frequent winds, or dies from loss of vitality, due to boxing, the sap wood rots away, leaving this light wood and the heart of the tree thoroughly saturated with resinous material, and capable of resisting the action of the elements for decades. Roots and stumps also become rich in these resinous products, and they were the first to be utilized in North Carolina, for the production of pine tar, by distillation. It soon became evident that there were considerable quantities of turpentine in the pine stumps, and many attempts were made to recover this, the earliest patent dating as far back as 1841. Very little was accomplished in a commercial way, however, until a plant was built in 1872 at Wilmington, N. C., for the destructive distillation of "light wood" and stumps. "Light wood" is exceedingly heavy, weighing 4,000 or 5,000 pounds per cord, and probably derives its name from the fact that it is particularly desired by the negroes for making their fires and for use as torches. When distilled, it should give all the products of "hard wood"—charcoal, acetic acid (recovered as acetate of lime), wood alcohol, gas and tar; but the tar being "pine tar," is much more valuable than the corresponding product from hard wood, and there is a much larger yield, due to the production of tar from the rosin present. In addition to all these products, there are obtained from 6 to 30 gallons per cord of spirits, depending on the quality of the "light wood." The tar, by further distillation, produces pitch, which finds a steady market, and tar oil, which, on account of its creosote contents, is worked up into disinfectants, cable-coating, sheep dip, wood preservative, shingle stain, etc. There is also a varying yield of wood oils, which find some market in the drug and essential oil trade. By basing their estimates of production of charcoal, acetate of lime and wood alcohol on the yields commonly known to be obtained from "hard wood," and for those of oil of turpentine, tar, tar oils, and "specialties" on the richest stumps and "light wood," it was easy to show on paper at least, a net profit of $50 per cord, which in a plant of ten cords per day meant $500 daily profit. With some such figures as a basis, a great many people were persuaded to embark in the destructive distillation of "light wood," but as soon as these plants were under way, a great many drawbacks appeared: (1) Their yield of wood alcohol proved to be only one or two gallons per cord, instead of 10 gallons per cord as commonly obtained from hard wood, and the cost of manufacturing wood alcohol from this source was found to be considerably in excess of the selling price. (2) The acetate of lime produced, was found to be comparatively small in quantity and poor in quality, the usual product being a brown acetate, which commanded a very much lower price than the regular commercial gray acetate, produced from hard wood. (3) The yields of oil of turpentine fell far below the estimates in most cases, and proved to have a very strong odor of creosote and aldehyde products, and great difficulty was found in marketing it at a satisfactory price. The objectionable odor could be removed in the main by treatment with sulphuric acid and caustic soda, but the yield was very much decreased by this treatment, and the resulting product, while having a fair odor, had lost noticeably in the valuable drying properties. (4) The various "specialties," from which so much was expected, usually overstocked the market after the first few gallons were sold. (5) The charcoal was ordinarily produced far away from blast furnaces, and the only consumption was that required for domestic heating in some not too distant city.

Many of these plants were finally abandoned; many more were accidentally burned; some are still standing practically in ruins. One which was built not many years ago at the cost of about $200,000, was sold as scrap within the last year for $20,000 or less. Of course, vigorous attempts were made to overcome the various defects, such as heating very gently until the spirits of turpentine had been distilled off and then increasing the heat; taking off the various products at different levels in the retort; regulating the heating by various devices, so that it should be evenly distributed throughout the retort; installing a great variety of patent separators to make the refining easier and more accurate. A few such plants are still in operation. The claim of some to be running at a financial profit, is probably due to the fact that these particular plants have worked up their tar oil into secret special compounds for which they have found a market.

Probably none of them is attempting to make wood alcohol; one at least is still making acetate of lime, and showed recently a net profit of 1 cent per cord and a capacity of seven cords per day. One small plant is using an asbestos-covered vertical retort in an endeavor to regulate the heat; another attempted to accomplish the same object by surrounding the retort by a huge oil bath. In the latter case material lying nearest the sides of the retort is charred before that in the center has been warmed up appreciably. The retorts used have been mainly of iron, varying in size from half a cord up to five cords capacity, and requiring from 36 hours to five days for the distillation of a single charge.

It seems to be evident from the above that primary destructive distillation is not the proper method to apply from a financial point of view.

The use of a hot bath in the retort instead of round it was patented by Johnson in 1865. This idea has been rediscovered and repatented within the last three or four years, and at least three plants working on this system are now in operation. The method usually adopted is to charge the retort with wood and then pump it nearly full of melted rosin, keeping the temperature of the rosin sufficiently high by blowing in superheated steam. When steam is allowed to blow through, it carries off the spirits of turpentine and with it a certain amount of wood oil and rosin oil. It has been stated that the yields from this process are as high as 30 gallons of spirits of turpentine and 40 gallons of heavy oil and rosin oil per cord, but in tests which the writer has witnessed, from 12 to 15 gallons of spirits of turpentine, 2 to 3 gallons of oil and 5 gallons of rosin oil might be considered average figures. The defects of this system are danger of fires and high cost of the process.

The next system to be generally exploited was the use of superheated steam, for which the oldest patent was granted to Hull in 1864. This process has been repeatedly repatented since, and there are now at least six such plants in operation. The usual method is to grind the wood in a chipping or edging grinder, place it in fairly large vertical retorts, and pass superheated steam through it until the spirits of turpentine and some of the oils have been entirely distilled off. In ordinary practice the superheaters are not regulated accurately, and the fires are very often allowed to die out. The method seems to have no particular advantages, and has the decided drawback of charring the wood where the superheated steam first enters the retort and so contaminating the spirits of turpentine with products of destructive distillation.

The first patent for removing the oil of turpentine from "light wood" by the use of steam without superheating was granted to Leffler in 1864. This apparently received no consideration for a great many years, and was rejuvenated by Krug a few years ago. Most of the plants which have recently been built, have used primary steam distillation to recover the spirit of turpentine, postponing destructive distillation or any other methods of recovering the other products from the wood until the spirit was removed. Future developments will probably be along similar lines. The principle used in this method is quite different from that of all the other systems, which heat the product in the wood high enough to boil off the spirit of turpentine. The success of a steam distillation plant depends first on the quality of wood; second, on the price for which it can be delivered at the retorts; third, the keeping of labor costs at the lowest possible figure by use of suitable retorts and machinery; and fourth, the proper penetration of the steam into the wood. The main development in recent years has been in the selection of suitable machinery and proper coordination of the different parts of the plant, and particularly in the designing of a retort which could be rapidly charged and discharged, and which would insure that the steam penetrated all parts of the wood without forming channels through it. Of the many retorts suggested, some are horizontal, charging through the top and discharging at one end; some are vertical, with various devices, more or less successful, for opening a large discharging door at the bottom; some use either a horizontal or vertical retort in which a cylindrical basket is placed containing the charge; and some have even attempted a continuous operation by charging and discharging all the time by mechanical devices; others still have used the idea of a retort hung on trunnions turned up to be charged and turned over for discharge; and others a horizontal retort with mechanical discharging device. At least two plants have attempted to use the system of running cars into retorts, something like the method used in "hard wood" distillation.

Many patents have been taken out covering the direction the steam moves in the retort, whether down or up, the introduction of the steam at various levels, and the agitation of the charge during the run; but the value of all these points is still doubtful. The time required for steaming out spirits of turpentine by this method varies from 1 to 12 hours in different plants. Yields vary from 6 to 25 gallons per cord, depending on the quality of "light wood" and the character of the plant, a fair average being from 12 to 15 gallons. When steam distillation is properly operated and the product is suitably refined, it would appear that the spirits of turpentine produced should not differ in any appreciable way from the old process spirits of turpentine or gum spirits of turpentine, the low temperature preventing action on the wood, just as in the case of the material which exudes from the tree in the old process.

There are now perhaps eighty plants in the United States for recovering spirits of turpentine from "light wood," and from mill waste. The products from the various plants vary not only on account of different methods employed in the plants, but mainly because the attempt is not made to produce material of a perfectly uniform standard; and in cases where this

* Abstract of a paper read before the New England Section of the Society of Chemical Industry.

is attempted the standards of different plants are different. When success has been attained along the line of standardizing the various methods of manufacturing, a spirit of turpentine produced in this way should be not at all inferior to gum spirits of turpentine; in fact, it should be superior on account of its uniformity.

After the wood has been treated by the steam process, it remains in almost exactly the condition in which it entered the retorts, excepting that the spirit of turpentine has been removed. A part of this refuse is used for fuel. The disposition of the remainder is a serious problem, because it cannot be destructively distilled in the ordinary retort without agitation on account of its poor conducting power. Some fairly successful attempts have been made to utilize it for manufacturing a low grade of paper, and for recovering the resinous material, but most of these attempts are still in the experimental stage. The point which has been definitely proven is that no destructive distillation can be attempted in the same retort that is used for distilling off the spirits of turpentine.

ASBESTOS.*

ITS PRODUCTION, USES, AND COST.

BY J. S. DILLER.

COMMERCIAL asbestos includes fibrous minerals of two distinct types. The true asbestos is actinolite or tremolite and belongs to the amphibole group, and with it may be placed the other fibrous amphiboles, anthophyllite and crocidolite. The more important asbestiform mineral, however, is the fibrous variety of serpentine known as chrysotile. Both fibrous amphibole and chrysotile possess qualities which peculiarly fit these minerals for use in the arts. The term asbestos, meaning non-combustible, thus has come to stand for mineral fiber which is more or less resistant to both heat and acids. Although the chrysotile, by reason of its chemical composition, may be affected by very high temperature and strong acids to a greater degree than the amphibole, the greater strength and flexibility of the chrysotile fiber make it the more valuable of the two. Thus, while mineralogically the amphibole variety is the true asbestos, the chrysotile is the standard asbestos of the trade.

The characteristics by which the two kinds of asbestos may be best distinguished are the yellow-green color and oily or greasy luster of the chrysotile and the unctuous feel of its soft, fluffy fiber, as contrasted with the white, gray, green, or brown color and harsher surface of the amphibole fibers. Prof. George P. Merrill has called attention to the angular cross section of the individual fibers in the case of the amphibole asbestos and the rounded or flattened outline of the silky fibers of chrysotile. The chief chemical difference between the several varieties of asbestos, all of which are silicates, is the presence of water as a more important constituent in the chrysotile. By excessive heating the chrysotile may be made to lose this hydrous condition, and then the fibers become less silky and their strength is impaired.

The amphibole asbestos occurs in association with the older eruptive and metamorphic rocks. Occurrences have been reported from most of the eastern States where there are areas of these rocks, especially Georgia, South Carolina, North Carolina, Virginia, Connecticut, and Massachusetts. Georgia, South Carolina, Virginia, and Massachusetts are the only eastern States where asbestos of this type is produced at present. Few accurate observations as to the exact nature of these deposits have been recorded, but it is expected that this subject will be given more attention in the near future.

The chrysotile asbestos has been studied more carefully. This variety is always found associated with serpentine, derived from the alteration of eruptive peridotite, pyroxenite, or other basic rock. It has been reported as occurring in commercial quantities in Massachusetts, Vermont, North Carolina, Wyoming, Arizona, Washington, Oregon, and California. The largest production is in the eastern townships of Quebec.

Asbestos fiber, aside from its variation in mineral composition and the rocks with which it is associated, has two modes of occurrence, according to which it is designated either "cross fiber" or "slip fiber." Cross-fiber asbestos forms veins in which the fiber in most cases extends directly across the vein, perpendicular to the vein walls. It is often silky and of high grade, ranging in size from a small fraction of an inch to 3 inches in length.

On the other hand, slip fiber occurs in slickenside fault planes, produced by the slipping of one portion of serpentine or amphibole rock along its contact with another portion, generally of the same rock. The fibers produced as a result of the slipping lie in the slipping plane, hence the name slip fiber. The mass of slip fiber in each slip ranges from a mere film to 4 or 5 inches in thickness, and varies greatly in quality from long, smooth, flexible, tough fiber, excellent for textile purposes, to short, harsh, brittle fiber, of small tensile strength.

Cross fiber is generally, if not always, chrysotile. As far as yet known definitely, amphibole does not occur in distinct cross-fiber veins. Cross fiber is for the most part of good quality, but slip fiber, though often of chrysotile, varies greatly in its properties. The brittle, splintery form appears to be amphibole. It is important to note that in serpentine, where the cross-fiber asbestos is all chrysotile, the slip fiber is frequently in part amphibole. In some of the Canadian mines much of the slip fiber is rejected on the ground that it does not work well with cross fiber of higher grade. In other mines by far the greater part of the fiber mined is slip fiber, and its quality may be excellent, though generally somewhat inferior to the cross fiber.

In both the Quebec and the Vermont localities the chrysotile forms irregular veins of cross fiber and sheets of slip fiber in the serpentine rock. These thin cross-fiber veins divide and coalesce, penetrating the massive serpentine in a complex manner. The accepted view is that veins of this character represent shrinkage cracks, due to partial dehydration with loss of silica, a process possibly facilitated by the proximity of igneous intrusions, as suggested by Cirkel.

In view of what is known concerning the origin of the two kinds of asbestos, Merrill makes the following pertinent suggestions regarding prospecting for asbestos: "The amphibole variety is to be sought only in regions of crystalline siliceous rocks that have been subject to more or less movement, such as is incident to folding and faulting. The serpentine variety, on the other hand, is to be sought wherever serpentinous rocks occur, and most hopefully where the same have been intruded by igneous dikes."

The uses of asbestos are many and constantly increasing. They depend primarily upon its fibrous character, but largely also upon its slow conduction of heat and electricity. As amphibole asbestos is less strong than chrysotile, the latter is the more valuable and useful, especially for products involving spinning. The amphibole asbestos is chiefly used in the manufacture of boiler lagging, steam-pipe covering, and insulating cements for general application. The best grade of chrysotile fiber is spun into thread, yarn, and rope, and woven into cloth. The yarn is largely used for packings and the cloth for theater curtains, while fabrics containing asbestos woven with other fibers are made into various household articles in which heat-insulation is required rather than fireproof qualities.

It is extensively used for plastering and for making lumber that is employed throughout buildings and especially on the roof, where insulation against fire and electricity are desired. Being a slow conductor of heat, its use contributes greatly to comfort and protection against extremes of heat and cold. Its application in fireproof structures, and especially to envelop electrical conductors, is rapidly increasing, and the demand is said to be much greater than the supply.

The output of asbestos in the United States for 1906 was 1,695 tons, valued at $28,565. This is a decrease of nearly one-half from the reported output for 1905. Approximately 1,540 tons of the output came from Georgia, Virginia, and Massachusetts, and is fibrous amphibole. The remainder, from Wyoming and Arizona, is chrysotile, as is probably also that of California.

While it is true that Canada produces 85 per cent of the world's supply of asbestos, and in a measure controls our asbestos industry, the advance in the price and the increasing demand should greatly stimulate prospecting for asbestos in the United States.

It is stated on good authority that "those familiar with the asbestos market are aware that the present supply of asbestos is not sufficient to meet the world's demand. This is principally due to the increasing uses and applications of the mineral for industrial purposes. It may be affirmed that the output of all the existing asbestos mines is insufficient to supply two-thirds of the demand for this product, and the leading manufacturing firms interested in the industry are diligently searching for new deposits."

The average price per ton of sales reported in 1906 is $16.86. This represents an increase of $3.04 per ton over the average price for 1905. The lowest price for actinolite was $8 per ton; the lowest price for amphibole asbestos was $17.61; and the highest price for chrysotile was $30, though some as yet unsold was estimated at $150 per ton.

The Canadian production of asbestos, wholly chrysotile, was 59,283 tons, valued at an average of $33.25 per ton, an advance of 23 per cent on the average price for 1905. Of this product, one-fifteenth classed as crude was valued at $165 per ton, and the remainder, called mill stock, at $24 per ton. The lowest grade of asbestos mine product is the "asbestic" of commerce. It is the rock which has been reduced to sand in the mill, contains some asbestos, and is used extensively for fireproof wall plaster. The production of asbestic from the Canadian mines in 1906 was valued at 85 cents per ton.

These prices afford data in estimating the value of asbestos deposits, but of greater importance is the relative proportion of asbestos in the rock mined. Cirkel states that an average of from 30 to 60 per cent of all the rock mined is suitable for milling. In the majority of the mills an extraction of fiber amounting to from 6 to 10 per cent of the milling rock is effected, and considerably less than one-half of this product will be fiber of spinning grades. The quantity of the higher grade crude asbestos usually secured by hand cobbing in the richest mines is from 1 to 2 per cent, although one or two mines produce a somewhat higher percentage. In a typical mine the asbestos produced amounted to 6 per cent of the rock mined, at a cost of over $17 per ton of product for labor, power, and supplies.

* Abstract from a bulletin issued by the United States Department of the Interior.

COPPER MIRRORS.*

By F. D. CHATTAWAY.

THE importance from the point of view of the health of the work people of obtaining a substitute for the tin amalgam used in the manufacture of mirrors has led many chemists to study the conditions under which metals are deposited from aqueous solution. These investigations have, however, usually had for their object the preparation of a liquid which would deposit a uniform and coherent layer of silver over a large glass surface at the ordinary temperature. Liebig was the first to solve this problem satisfactorily, and his method in which milk sugar is the reducing agent was formerly extensively used.

Other metals are not so easily deposited, and copper, which from its close relationship with silver one would expect to behave similarly, has never been observed to be so laid upon glass. Although copper mirrors have never been obtained by deposition of the metal from aqueous solution, Faraday, about the time when silver mirrors were attracting much attention, made the interesting observation that a mirror-like deposit could be obtained by dissolving a little oxide of copper in olive oil and heating plates of glass in a bath of this liquid up to the temperature at which the oil decomposes. The mirrors, however, obtained by Faraday's method, if of any size, are liable to be stained or discolored in patches by decomposition products of the oil, and they are, moreover, generally lacking in brilliancy. Further, as the deposition of the metal only takes place when the oil decomposes, the process is excessively disagreeable to carry out; and since the oil is spoiled it is also somewhat costly.

In the course of an investigation on the oxidation of aromatic hydrazines, the author observed that when solutions of cupric oxide are reduced by these compounds the metal is deposited upon the glass in the form of a brilliant coherent film if clear vessels are used.

The mirrors obtained by this method are very beautiful, as they show the lustrous red color of burnished copper, and are as perfect in reflecting surface and as uniform as the similar mirrors obtained by the deposition of silver.

It seems probable that this method of depositing copper upon glass could receive important application in the production of objects of art.

* Abstract from a paper read before the British Association.

The Union Pacific Railroad as a result of tests with the experimental all-steel box car recently built in its Omaha shops, has commenced the construction of twenty-five more. The weight is 37,800 pounds, lighter than the standard wooden cars used on the Harriman lines, and the capacity is 50 cubic feet more. The steel car will require fewer visits to the repairing shop, and will protect goods better in transit. A 15-inch steel I-beam forms the center sill of the car below the double steel flooring. Actual tests have shown that the ¼-inch sheet steel forming the sides and ends of the car is stronger than the wood usually used. The doors of the steel car are formed by single sheets of steel reinforced, like the sides and ends of the car, by diagonal bracing.

THE SPARK METHOD FOR GRADING STEELS.

A CONSIDERATION OF THE APPLICATION OF TESTS FOR STEEL BARS.

BY ALBERT F. SHORE, M.E.

How many steel men and toolmakers are there who can tell exactly what kind of steel is in a bar if the familiar signs and labels have been marred, or if the specimen has become a little rusted? Most toolmakers prefer to chip a piece of the bar with a cold chisel, heat and chill it, and if it hardens it must be tool steel. In these days of high-carbon machinery steels and in view of the fact that small bits of steel harden more easily than larger pieces, these tests are often misleading, inasmuch as high-carbon machinery steel will harden enough to resist the file, and thus test like tool steel.

The method which I will describe depends on the action of the oxygen of the air on the more combustible elements contained in different steels, which tend to act explosively when the proper temperature has been reached. To produce a bright spark as the result of heating microscopic particles of metal, as by grinding or by casting filings into a flame, certain conditions are necessary to insure success. In the former, there must be enough strength to resist wear or cutting in order to heat the detached particles, and this heat must be intense enough to cause oxidation, while in the latter case, the metal must be subject to combustion at the temperature of the flame, without volatilization, before any amount of light is produced. Now the action of grinding or of a candle flame cannot produce heat enough to volatilize iron or steel, but the heat imparted is ample to cause chemical combination between the oxygen of the air and the iron, which in the process of combustion causes heat of sufficient intensity to ignite the carbon contained in iron, and especially steel.

This fact is beautifully demonstrated by the iron torch, shown in Fig. 2. By heating a bar of iron to a welding heat and then holding it in a strong air blast, it will at once begin to boil and sizzle, emitting a dazzling bluish-white light. This may be maintained for hours without any source of heat, except that ity is probably due to the action of the oxygen on the heated particles requiring some time to act. This effect is at its maximum when the spark streak appears broadest and whitest, and would continue so, but for the reason that the fuel supply is soon exhausted.

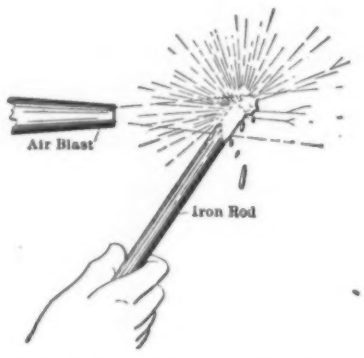


FIG. 2.—AN IRON TORCH.

By adding a very small percentage of carbon to iron the effect is at once noticeable by a division or forking of the luminous streaks, as in 2 of Fig. 1. This is owing to the presence of the carbon, which is only acted on by the maximum heat of the iron spark, and which then burns explosively, causing a break in the original heavy line. By adding more and more carbon to the steel, the iron lines become less and less conspicuous, and the star-like explosions do not only become extremely profuse, but their rays often divide again and subdivide, causing a beautiful display of curves and figures, as in 3 of Fig. 1. In this instance it should be stated that the iron and carbon have been so united that they are most easily attacked by the

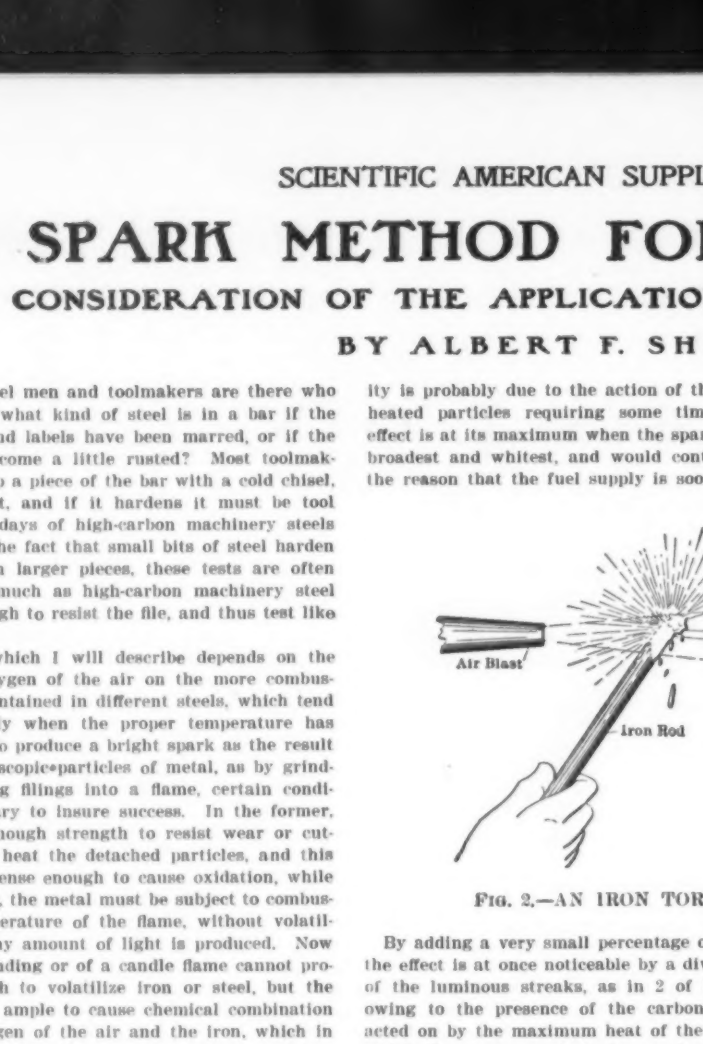

Iron Wrought 1
Mild Steel or Low Carbon 2
Tool Steel or High Carbon 3
High Speed Steel 4
Manganese Steel or Iron 5
Capital Steel 6

FIG. 1.—SPARKS FROM IRON AND STEEL.

caused by the combustion of the iron. Beginning with let us say sing iron, which is almost free from carbon, the spark test will usually give straight lines, which become broader and more luminous some distance (not over a few inches) from their source, and then disappear as they started (see 1 of Fig. 1). This peculiar- oxygen, and hence the great danger of burning tool steel in the process of forging. This readiness to burn may be considerably reduced by the addition of a more refractive metal as tungsten or molybdenum. The former alloy shows not only anti-rusting qualities, but also can endure incandescent heat without scaling or burning. The temper is thus not drawn so easily and hence the name high-speed steel.

In the spark test these peculiarities are shown as indicated by 4 and 6 of Fig. 1, in which the sparks appear not only simple, but also very dull red. This, however, is easily understood by referring to the foregoing paragraphs where it is shown that the luminosity of iron or steel sparks depends for the most part on the combustion of the iron and carbon. Perhaps one of the most remarkable sparks which enter into this group is characteristic of manganese and widely differs from the familiar carbon stars and rays. Once these diversified signs have been carefully studied, the trained eye will detect the slightest trace of manganese in even what is otherwise a pure carbon steel. Its spark is shown in 5 of Fig. 1. The lateral darts always radiate from an unbroken line and at right angles thereto. The color is dull red and each dart is subdivided into a number of white-hot globules.

Some steelmakers use the method of spark analysis in testing their products, in addition to others, and they agree that it is very reliable.

There are, also, many mechanics who by experience have learned thus to distinguish tool steel from iron or machinery steel, and who are never caught making reamers and cutters of machinery steel, and bolts and screws of tool steel. Most mechanics, seeing a variety of sparks as here shown among different irons and steels, have failed to distinguish any special significance in any particular one, and they on the average are unable to identify a favorite grade of steel by the spark. Perhaps the most misleading spark to be found is the one of gray or cast iron, which being very seldom of a standard purity will often show scarcely any luminous sparks at all. Sometimes it is rich in manganese, and the familiar bright manganese darts are given off at varying distances from the source of heat. Cast iron usually consists of iron with a very high percentage of carbon, which gives it rigidity and hardness. Graphite in iron is that form of carbon which is not chemically united and, therefore, it follows that since it exists in a free state, it must be present in all stages of combination. Thus cast iron will yield sparks ranging from iron to tool steel. In addition to the diversified sparks shown in the diagram there is also much significance in the distance in which they appear from the source of heat as in grinding, which is the most accurate test.—American Machinist.

ABOUT MEERSCHAUM.

A SUCCINCT account of what may be called "the smoker's mineral" appears in The Bookseller, Newsdealer, and Stationer (New York). Meerschaum, we are told by the writer, is a hydrated silicate of magnesia appearing as an opaque earthy mineral, white grayish, or yellowish, compact in texture, and breaking with a conchoidal or fine earthy fracture. He says:

"Most of our meerschaum comes from Asia Minor, especially from the plains of Eskischehr, where it occurs in nodular masses of variable size and irregular shape, distributed through the alluvial deposits of the plain, which are systematically worked for its extraction by means of pits and galleries.

"Meerschaum is found also, but less abundantly, in Greece and in some of the Grecian islands; at Hrubschitz, in Moravia, where it occurs in a serpentinous matrix; and in Morocco, where it is used, when soft and fresh, as a substitute for soap; while a coarse variety is found at Vallecas, near Madrid, and is employed as a building-stone. Meerschaum also occurs in South Carolina. Almost the whole of the world's supply of meerschaum comes from the district of Eskischehr, in Asia Minor. The principal places of production are within six hours' journey from that town, and the best mines are Sepedschi, Saricu, Odhsack Konigli, and Jarmarlar; but there are about 2,000 points where meerschaum is extracted. The workmen employed are for the most part Kurds and Persians, and they number about 4,000. Mining is done in a primitive fashion, and precautions for safety are unknown, although accidents occur from time to time. A group of three to fifteen workmen work together to dig a shaft about one meter in diameter, and no props are fixed until they reach, at a depth of 20, 40, or even 60 meters, the bed of red clay under or in which the meerschaum is found, mixed with serpentine in the form of irregular pieces from the size of h hazel-nut to that of an apple. These pieces are often extracted with great difficulty, after making long galleries in the red clay. In many places the earth is mined in such a way that the galleries of several different excavations are confused. The work is carried on day and night, the workings being lighted by means of oil-lamps. . . .

"The meerschaum is not sold by weight, but by the case or box. After the purchase, the meerschaum, which is damp, heavy, and of a yellowish color, is set to dry in the sun in summer time, and in the winter for about nine days in a drying-oven heated day and night. The product loses about two-thirds of its weight in the drying, and becomes snow-white. Afterward it is rubbed with flannel, moistened with warm water, any roughness is removed with a knife, the hollows are cleaned with sand, and finally the pieces are polished with wax.

"In this condition the meerschaum is sent to market. The pieces are graded into four classes, according to their quality and size. . . . The grading having been carried out, the pieces are wrapped in cotton wadding to avoid scratching, and packed in boxes of various sizes, containing from 32 to 40 pieces of the first quality, to 75 to 90 pieces of the second quality; 100 to 200 pieces of a third quality fill a large box; and a fourth quality 200 to 400 pieces per box."

ELEMENTS OF ELECTRICAL ENGINEERING.—I.

THE ELECTRIC CIRCUIT—ELECTROMAGNETIC INDUCTION—THE MAGNETIC CIRCUIT.

BY A. E. WATSON, E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY.

ELECTRICAL engineering places great reliance upon physical and mathematical sciences. The dependence has, however, been mutual. Discovery and experiment have often led the investigator into a maze of conflicting ideas from which the mathematician alone could point out and extend the way; while abstruse deductions and apparently imaginary equations, of only academic value, have been shown by the engineer to have physical existence or to interpret real experience. In no field have theory and experimental evidence been more closely linked together in helpful and harmonious agreement. Hesitation to accept new interpretations has sometimes been felt in this as in other lines, with the result of the more clearly separating the essential from the accidental and giving greater emphasis to the truth.

The electric battery was invented by Volta, an Italian, in 1800, and the discovery of the "circuit" that could be established marked the beginnings of "current" electricity. Contemporary experiments by Galvani have often been misinterpreted and their importance over-estimated. Volta's batteries were few in number, of small size and high internal resistance; the current, therefore, was small, but the incentive given to new lines of research was great, and pioneer contributions to the theory and explanations of the action of the so-called fluid were made by Ampère, Coulomb, and Laplace in France, and by Weber and Gauss in Germany. To Coulomb is due the statement of the first of four fundamental laws of magnetic and electrostatic action, known as "the law of the inverse squares"; by it is meant that two magnetic poles or two electrostatic charges attract each other with a force directly as the product of the charges, and inversely as the square of the distance between them. In 1801, Davy made his celebrated battery of 1,000 cells occupying, probably, as much space as some modern storage battery installations; with it he exhibited the electric arc between charcoal points, and for the first time there was revealed an expression of the great energy in artificially produced electricity. In some lines of human achievement a century has produced how little, in electrical engineering how much! During the next generation, no particular improvements were made over the ingenious theories and curious speculations of other scientists; but there were discoveries of far-reaching importance, and mathematical definiteness began to displace unguided guesswork.

In 1819, a discovery of remarkable character was accidentally made by Oersted, of Copenhagen. Close to the wires from the batteries, he had a number of delicately pivoted compass needles; whenever the circuit was closed, the needles were observed to be deflected from their correct direction. Investigation of the conditions showed that if the current passed directly over a needle from north to south, the north pole was deflected toward the east (see Fig. 1); if under the needle, toward the west; if the current passed over, and then returned under the needle, the deflection toward the east would be with twice as much force as the single passage. Strong currents through several turns would hold the needle at almost right angles to the wire. This manifestation of a force at right angles to the plane of the current is seen to be another instance of the general principle of electromagnetism, for with that, a current *around* a coil sends magnetic lines *through* the coil. The immediate bearing of Oersted's discovery was to supply the means of detecting the presence and direction of currents of electricity, and if the instruments were suitably graduated or calibrated, actually to measure the strength of the current. Nobili, of Italy, made very delicate constructions, and sought to honor the memory of his fellow countryman by calling them "galvanometers." In modern engineering the interference of large currents with the readings of switchboard instruments is often avoided by using iron cases; with such shields, the stray lines of force may enter the iron, but not pass through the region within.

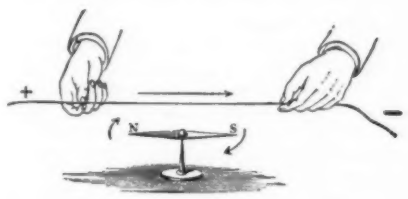


Fig. 1.—Deflection of a Compass Needle with an Electric Current.

In the year following Oersted's discovery, Davy and Arago independently found that a piece of iron placed within an active coil or helix would become magnetic —temporarily if the iron was soft, permanently if hardened steel was used. At once the means was available for making strong magnets for compasses and other purposes without dependence upon the natural magnets, or "lode-stones."

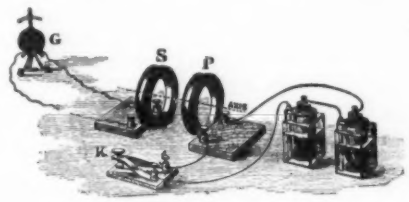


Fig. 2.—Apparatus Showing Discovery of Electromagnetic Induction.

Just what conditions determined the strength of a current and in what units to measure it was an open, and for a time, baffling problem. For years, noted scientists worked with all sorts of combinations of wires and batteries, and made records of the galvanometer deflections, hoping from the accumulated data to derive some fundamental law; the figures were sufficiently varied to suggest some complicated conditions. But Ohm, in 1826, made his celebrated simple solution. He introduced the two ideas of the electromotive force, or pressure, which drove the current and the resistance through which the current flowed. He then stated that "the current was directly proportional to the electromotive force, and inversely proportional to the resistance of the circuit"; in other words, the greater the moving force, the greater the current; the greater the resistance, the smaller the current. This result was no more than was expected, but the experimenters before Ohm missed the essential point of including the whole of the resistance of the circuit; they omitted the resistance of the battery itself, and often this factor was the largest item; without its consideration the computations were certainly interminable. But Ohm was a young man, and his law so suspiciously simple that the leading German scientific magazine refused to publish it, and it first appeared in an English journal. Though he did not propose any definite units, such as are now associated with its application, the law quickly won acceptance, and remains as the second of the rigid and most fundamental laws of electric action.

Further connections between currents and magnets than were found by Davy and Oersted were suspected, and Faraday, the assistant and successor of Davy, in 1831 made the discovery of "electro-magnetic induction"—the principle upon which all dynamo electric machinery depends. By a mere reversal of the proper order of procedure, he missed making the discovery three years earlier. The apparatus consisted merely of a battery, two flat coils, and a galvanometer. Faraday first established the current through one coil, then laid the second coil on the first and then attached the wires of the second to the galvanometer; there was no movement of the needle, indicating no action between the coils. When later he attached the wires to the galvanometer before establishing the current in the first coil, he obtained a violent deflection; the result was mystifying, but invariable; it was certain that the act of starting a current in one coil immediately produced one in the other; still further, when the current became steady in the first coil, all action ceased in the other, but breaking the current in the first coil also produced a current in the other, yet in the opposite direction, and if anything of greater intensity; indeed, any increase or decrease in the strength of the current in one coil produced proportionate currents in the other; or with a steady current in one, mere changes of position would generate currents in the other. In general, with the terminals of one coil attached to the battery, and of the other to the galvanometer, it was impossible to make any relative changes of position whatever without generating a current. (See Fig. 2.) To interpret the phenomenon in the light of his later conceptions, the current in the first coil set up lines of force, which permeate the coil and extend in curves of increasing radius into the neighboring region; a second coil brought within the reach of these lines experiences the "induction." Faraday gave definiteness to his discovery by denoting the coil which received the current from the source as the primary, the one in which the current was induced as the secondary; these names still persist in connection with transformers, induction coils and "induction" motors.

If the secondary circuit is not closed, of course no current can flow in it, but the same electromotive force would still be generated at every change of the primary current; if closed, the current that flows will be in the same measure as if the electromotive force came from any other source. It is a matter of common experience that there is always the full pressure in the secondary circuit of a transformer, even though no lamps be lighted. Expressed in brief form, Faraday's law—the third in the list of the fundamental—is that "an increase in the primary current induces an electromotive force in the secondary circuit in the direction opposite to the primary current, that a decrease induces one in the same direction as the current, and that the numerical value of the electromotive force is directly proportional to the rate of change of the primary current." If iron is present within the coils, the number of lines of force and consequently the induction and electromotive force will be greater. With ordinary alternating currents supplied to the primary of transformers, electromotive forces of equal value are induced successively in the secondaries, but ordinary "induction-coils" that are operated by rapidly interrupted battery currents generate electromotive forces in one direction greater than those in the other; this condition is due to the physical fact that such a primary current can be broken rather more quickly than it can be established.

The energy expended in an electric circuit can mathematically be shown to be proportional to the "square of the current and directly as the resistance of the circuit," and Joule has experimentally shown this to be the truth. Why this should be the square of the current instead of its simple value is something of a surprise to a beginner, and a physical explanation is not entirely available. An illustration can, however, be given. It is true and reasonable that the amount of zinc dissolved in a battery is directly proportional to the current flowing. Suppose a number of cells are connected in series with such a high external resistance that the internal resistance of the battery is negligible in comparison with it: practically all the energy will then be expended externally; if now it is desired to double the current, the number of cells must be doubled, and if twice as much current actually flows, twice as much zinc will be dissolved in each cell; and since there are twice as many cells, the act of doubling the current has required the consumption of four times as much zinc. The expenditure of energy in driving a current through a resistance is identical with mechanical energy in overcoming friction—

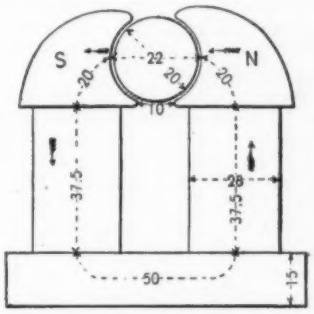


Fig. 3.—Typical Magnetic Circuit, Figures Showing Dimensions, Etc.

it is an irrecoverable waste and manifests itself as heat. In particular cases the heat may be radiated into the surrounding medium as fast as it is generated, and result in no appreciable rise in temperature, as with a trolley wire, or reasonably warm conditions may be met as in the coils of a dynamo, or from extreme cases, where the heat is desired, in the incandescence of the lamp filament, or the fervor of the electric arc.

Upon these four laws, derived from experimental evidence, the whole theoretical treatment of electrical science depends. Resting upon such indubitable ground no suspicions need be entertained of the accuracy or sufficiency of well considered though lengthy mathematical deductions. With the mere addition of a convenient and consistent system of units in which to express the various quantities, the various problems can be treated by well known processes.

Units in which to express values of the electromotive force, resistance, and current had been proposed by the British Association, and previous to 1881 were in common use in England and Germany. They were, respectively, the "volt," "ohm," and "weber," and were known as the B. A. units. In that year, the first International Electrical Congress was held, in Paris, but the attempt to adopt all of these names failed. Still rankling with the memory of the Franco-German war, the French delegates would not allow two German and no French name to be thus commemorated, and the "ampere" was substituted for the "weber." Further, the unit "coulomb," along with the "joule" and "watt," was adopted. A non-committal name, the "quadrant," as a unit of self-induction, was accepted. Consequently, as far as national allotment was concerned, England had two units, France two, Germany and Italy one each, but at the Congress in Chicago in 1893, the quadrant was displaced by the American name "henry." Names to express magnetic units have also been proposed, notably by the American Institute of Electrical Engineers, among which the "weber" was resuscitated; but at the Paris Electrical Congress in 1900, the French still opposed the German name, and as a compromise, the English "maxwell" was adopted. Gilberts, gausses, and oersteds also appear among these later units. Though accepted, they are not in very general use, even in academic circles.

As defined in Chicago, and subsequently adopted by most of the civilized nations, the "ampere" is that rate of flow of current which from a nitrate solution will deposit about 0.001 gramme of silver per second; the ohm by the resistance of a column of mercury of one millimeter cross-section and 106.3 centimeters in length; the volt, while mathematically defined by the multiplication of one ampere by one ohm, is physically determined by reference to a "standard" cell; when set up accordingly to a stipulated formula, the electromotive force of a "Clark" cell is 1.434 volts. Following the convenient though erroneous conception of electricity as a fluid, and that a certain rate of flow maintained for a definite length of time results in a certain quantity, a "coulomb" is the resulting quantity of electricity when one ampere has flowed for one second. The joule is the unit of work, and the rate of doing work, one joule per second, is the watt. Numerically the watts are equal to the product of the volts times the amperes. Seven hundred and forty-six watts can be shown to be equivalent to the mechanical unit, the horse-power. One thousand watts equal one kilowatt, a rather more convenient unit for large machines. The names of the units are therefore seen to represent a sort of graveyard, in which by reason of unexpected national jealousies, and by preference for short words, some noted scientists have been omitted.

After dynamo building had become an established art, a serious lack was felt regarding lack of information pertaining to electromagnets. The cut-and-try method of proportioning a machine is expensive and unscientific; but to know just how much magnetism was produced by a given current, or just what amount of iron, copper and current was needed to produce a magnet of given strength was a matter largely in the dark. In 1873, H. A. Rowland, then in Troy, N. Y., proposed a method of treating magnetism as operating in a circuit, just as Ohm had successfully demonstrated for the flow of electricity. The suggestion did not take very deep root, however, for the author was only just graduating from college, and senior theses are not supposed to be taken very seriously. Ten years later, Dr. Hopkinson, of Manchester, Eng., adopted the same idea in a definite manner, and by it predicted, for the first time, the operation of a proposed dynamo. The machine was then built, and tests were publicly made and compared with the original predictions; the results amply confirmed the correctness of the method of the computations. It is often denoted as "Hopkinson's law," but Prof. Rowland is now admittedly the real author of its conception.

When the electromotive force and resistance of an electric circuit are given, it is merely a matter of division to find how much current will flow. Likewise, if similar quantities for a magnetic circuit are known, the number of magnetic lines or the "flux" can be determined. The expression "ampere-turns" was early in common use, meaning the product of the number of turns of wire and the current flowing in it; from theoretical considerations of the definition of a unit pole and the work done when such a pole is carried through the axis of an active helix, the quantity, 1.25 times the ampere-turns is found and called the "magneto-motive-force" for that particular case. This is a force tending to drive magnetism, just as electromotive force tends to drive electricity; just how much will flow in either case depends upon what obstacles are in the way. In order to adopt a distinctive name, yet suggestive of the property and application of the electric case, the name "reluctance" has been given to specify the magnetic case. Just as the electrical resistance of a given wire is computed by dividing the length by the cross section, and multiplying this quotient by the specific resistance or dividing by the "conductivity" of the particular material at hand, so the magnetic reluctance of a circuit can be obtained by dividing its length by the cross section and again by the "permeability" of the material. This essential difference exists between the two cases—and until recognized, it is the cause of much confusion—that whereas the conductivity of a wire, if the temperature is kept constant, is the same, independent of the value of the current, the permeability of iron to magnetic lines depends upon the density, or closeness together, of those lines; for low degrees of magnetization, the iron is very permeable; for high degrees, the condition of saturation is approached, at which even very great magnetizing forces fail to produce essential increase in the flux. Ewing, in England, has conducted extensive investigations into the behavior of iron, of all kinds and grades, under wide ranges of magnetizing forces, and has plotted the results in curves that are accepted as standard. From these curves it is now as simple a matter to find the reluctance of a piece of iron at a given flux density, as it is the resistance of a wire from a wire table.

If the magnetic circuit consists of one mass of iron of uniform section, the reluctance could be obtained by a single calculation; but ordinarily, as for dynamos, the path for the lines of force will lie through several different materials, each having its own length, section, and permeability; each element must therefore be determined separately and the results added to obtain the total reluctance. The case is like that of an electric circuit consisting of a number of different kinds of wire soldered together, each having its own length, section, and specific resistance; the resistance of each part would then need to be computed, and the results summed. In the design of a dynamo, a certain flux of force is specified as wanted, and the problem therefore consists in determining what kind, amount, and arrangement of materials, and what number of ampere turns will produce that flux. The formula is therefore reversed, but capable of direct solution, for the assignment of a definite flux through a definite section of material leads at once to the application of the saturation curve. As all the electrical and magnetic quantities are derived from the centimeter-gramme-second (C. G. S.) system, a builder must be cautioned to make the proper transfer if he uses the English units. (See Fig. 3.)

Some explanation has hereby been attempted of fundamental facts and principles of electrical engineering. These are possibly a little tedious to follow, but they will endure re-reading and extension in more adequate books. They are essential to a satisfactory progress in the subject and to a working familiarity with electro-technical literature.

The second article will consider the construction and principles of operation of direct current dynamos.

(To be continued.)

An interesting experiment to determine the efficiency of ferro-concrete groynes for the prevention of erosion of the foreshore is being made at Brighton on the south of England coast. Hitherto timber has been almost exclusively employed for this purpose, but the objection to this material is its liability to decay. One groyne is being built in ferro-concrete, the Hennebique system having been adopted. The piles, having grooves on either side, are spaced along the beach in a line extending from a point above high water to another below low water. In the grooves of each adjacent pile slabs of ferro-concrete are inserted in such a manner that they are free to slide vertically downward in case the beach immediately beneath should be scoured away. When the groyne has arrested sufficient material brought up by the tides so as to reach the top of the lower layer of slabs, other similar slabs are then slipped into position in the pile grooves, a building-up system thus being provided for increasing the height as desired at frequent intervals, the piles being made sufficiently long to admit of such additions. At those points where the beach was hard solid rock, holes were excavated for the insertion of the piles, which were then surrounded by concrete well rammed down, but wherever steel or wooden piles could be driven by the usual methods, the same process was followed with the ferro-concrete piles with complete success.

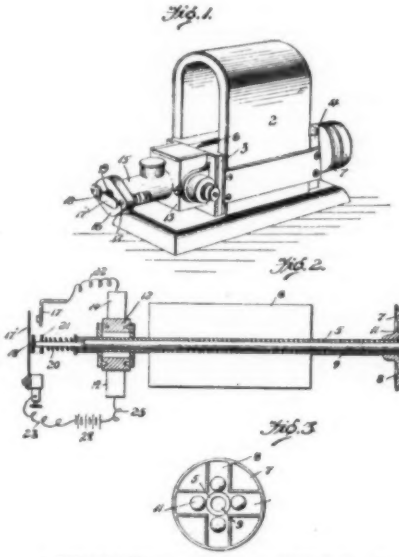
AUTOMATIC SPEED CONTROL FOR MAGNETO.

An ingenious mechanism which will permit a magneto generator to maintain automatically the electric charge of a storage battery, particularly a battery used for the igniting apparatus of an internal-combustion motor, has been invented by Charles E. Dawson, of Indianapolis, Ind., and a United States patent has been granted covering the invention. The invention is also applicable for charging any secondary battery in which the motive power used to operate the generator is irregular.

In the group of drawings Fig. 1 is a perspective view of the invention, Fig. 2 a horizontal section in a plane through the armature shaft, showing the circuit to the storage batteries, and Fig. 3 a detail view of the governor.

The shaft (5) of the armature (6) is hollow, and upon one end of it is mounted a peripherally grooved pulley or disk (7), which is connected by a belt or other transmission device to an internal-combustion motor or irregular motive power. Extending through the hollow shaft is a spindle (9), the end adjacent the pulley (7) being provided with a disk (10). The face of the disk opposed to the grooved face of the pulley is provided with a number of radial grooves (8), the opposed grooves forming tapering radial raceways between the two parts. In these raceways are located balls (11), which when the armature shaft is driven at a certain predetermined speed fly by centrifugal force toward the peripheries of the pulley and the disk and cause the disk to move axially away from the pulley. As the disk is rigidly secured to the spindle (9) the spindle also moves axially.

The commutator (12) is on the end of the armature shaft opposite from the governor just described. To a disk (16) at the end of the commutator housing are



AUTOMATIC SPEED CONTROL FOR MAGNETO.

attached contacts (17) and (17'), the latter being a spring tending to move toward the former.

The under face of the contact (17') is provided with insulation (18), which lies directly in front of an opening (19) in disk (16) and which is adapted to be engaged by the end of the spindle (9) projecting through the opening. To hold the end of the spindle against the insulation there is a helical spring.

The contact (17) is connected directly with one of the brushes (14), while the contact (17') is connected with storage batteries (24), which are in turn connected with the other brush.

It will be noted that the spindle is normally held by the spring (20) in such a position as to provide an open circuit through the storage batteries. When the speed of the generator increases to such an extent that the voltage has reached a predetermined point the centrifugal governor draws the spindle away from the circuit-closer (17'), permitting the latter to move to contact (17) and to make a circuit from the generator through the storage batteries, and when the voltage falls below the predetermined point the governor will permit the spindle to move and break the circuit.

Thus it will be seen that when the irregular power is running at high speed the storage batteries are charged, and when the power is running at low speed the generator does not charge the batteries. By this means it is impossible for the batteries to discharge through the generator, as at no time when the circuit is closed does the electromotive force of the generator fall below that of the batteries.—Western Electrician.

To Remove Verdigris Spots from Gilded Objects.—Rub the spots smartly with a small wad of cotton dipped in ammonia. Wash with soapy water and dry in sawdust.

Correspondence.

WIRELESS TELEGRAPHY.

To the Editor of the SCIENTIFIC AMERICAN:

My attention has been called to an article by Mr. W. Maver which appeared in the SCIENTIFIC AMERICAN SUPPLEMENT of August 10, 1907.

In this article Mr. Maver attributes to me opinions and statements which are the exact opposite of those actually held and made by me.

As an illustration, Mr. Maver states that I have "practically admitted that the difficulties of trans-Atlantic wireless telegraphy are at present well-nigh insurmountable."

What I actually said, in my article which Mr. Maver refers to (SCIENTIFIC AMERICAN, January 19, 1907) was: "Wireless telegraphy is able to compete with cables to-day in any part of the world and to give better service and at lower prices"; and I went on to show that the sole difficulty at present is the impossibility of obtaining licenses to operate.

In view of the fact that I have been able to maintain wireless communication between Brant Rock and the West Indies, a distance of nearly 1,700 miles (or nearly the distance between Ireland and Newfoundland) during daylight and in summer weather, I do not consider that the question of the possibility of transatlantic wireless telegraphy is a debatable one.

Again, so far from stating, as Mr. Maver says, that the prospects for overcoming the difficulties of selectivity are not very encouraging, what I actually said was: "As regards the question of interference, this ceased to be a vital question two years ago." Our Washington station, for example, has been operating with another station, 400 miles away, for several years now, in spite of the fact that it is only 1¼ miles away from the large navy station at the Washington navy yard, the interference being cut out to such an extent that it is not possible to tell when the navy yard station is operating, except by throwing out the interference preventer.

Mr. Maver's statement that "much remains to be done before wireless telephony, even for short distances, becomes an accomplished fact," may be compared with the statement of the editor of the American Telephone Journal (editorial February 2, 1907) that "the transmission during the recent test was so clear as to make it evident that a distance sufficient for many thoroughly practical uses can now be obtained *without further modification, even of detail*."

Mr. Maver's statement that wireless telephone messages have only been transmitted for a few miles is not correct, as distances of 25 miles were reached some years ago, and wireless telephone stations have now been in operation, in daylight over a distance of nearly 200 miles, for several months.

I regret the necessity of thus criticising Mr. Maver's article. It is true that I have made a practice of communicating to scientific journals the various difficulties met with, because I consider it not only due to the scientific public, but also to the best interests of the wireless companies themselves that the exact state of affairs should be known and not concealed.

The opinions, however, attributed to me by Mr. Maver are so diametrically opposite to those held and published by me, and their promulgation liable to be so injurious to the interests of wireless telegraphy, that I have considered it absolutely necessary, both for my own sake and that of the general public, not to allow them to go uncorrected.

REGINALD A. FESSENDEN.

Brant Rock, Mass., August 22, 1907.

POTASSIUM CHLOROPLATINITE FOR PHOTOGRAPHIC USE.

By RUDOLPH BOLLING.

IN the printing process in photography very beautiful and the best permanent effects are produced by "toning" the silver positive in a bath of the double chloride of potassium and platinum. The chemistry of the process is very simple. The platinum salt reacts with the ferrous oxalate and silver salts, with the reduction of the platinum to the metallic condition on the image, thus: $3K_2PtCl_4 + 6Fe(C_2O_4) = 3Pt + 2Fe_2(C_2O_4)_3 + 2FeCl_2 + 6KCl$. The most costly reagent used is of course the platinum salt, and it seems from my experience that the dealers in photographic supplies charge from 50 to 70 per cent more than the price of the metal platinum would warrant. I would therefore strongly advise those who use the platinum process to prepare their own potassium chloroplatinite, and thereby effect a saving and also secure the salt absolutely chemically pure.

SYNTHESIS OF POTASSIUM CHLOROPLATINITE.

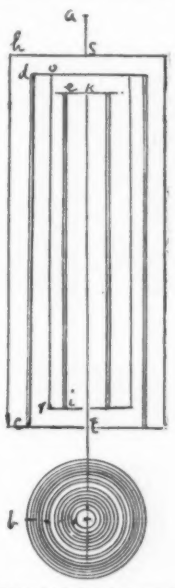
Platinum scrap can be obtained from electrical houses or refiners at the market price, which at present is from $0.80 to $1.10 per gramme. Into a one-liter Jena flat-bottom flask 10 or 12 grammes of scrap are placed, and on this poured 300 cubic centimeters of strong nitric acid and 400 cubic centimeters of strong hydrochloric acid. Chemical action is set up at once by the action of nascent chlorine and nitrosyl chloride, thus: $HNO_3 + 3HCl = 2H_2O + NOCl + Cl_2$, and is greatly promoted by setting the flask upon a warm surface, such as a hot water radiator or similar appliance. After a day or two the platinum will have been dissolved to a clear red liquid. The flask must now be brought to a boil over a burner, and the excess of acid removed and the boiling continued until the solution becomes concentrated to a syrup. Water is now added sufficient to dissolve the platinic chloride, and the solution poured into a half-liter beaker.

A solution of potassium chloride is now prepared by dissolving 100 grammes of this salt in one liter of water, and this solution is gradually added with vigorous stirring with a glass rod to the platinic chloride solution in the beaker. Beautiful golden-yellow crystals of potassium chloroplatinite will begin to form at once, and will settle to the bottom in a yellow crystalline mass. A glass 7-centimeter funnel is now fitted with a 9-centimeter filter paper, and the contents of the beaker filtered, the paper of course retaining the platinum precipitate. This is washed with strong alcohol, in which it is almost perfectly insoluble, three or four times, in order to free the potassium chloroplatinite crystals from any excess of potassium chloride, as it is well to use about 300 cubic centimeters of potassium chloride for a solution containing this amount of platinum in solution. The funnel and its contents can now be left to dry, which will take place in a short time from the use of alcohol as a washing liquid. After the paper is dry the crystals can be transferred to a small glass bottle for future use. It is not necessary in this process to use chemically pure platinum or acids, as the process in itself is a natural refining method, but the salt produced is strictly chemically pure. The amount of potassium chloroplatinite produced by this method is quite surprising, 1 gramme platinum making 2.4941 grammes of the double chloride. Most "toning" formulas are simply a solution of this salt in water. One that I generally employ is 240 cubic centimeters of water, 10 cubic centimeters of syrupy phosphoric acid, and one gramme of potassium chloroplatinite.

NOTE ON THE GRIDIRON PENDULUM.*

By C. F. ADAMS.

THE gridiron pendulum is practically out of date; but for many years it has been a favorite illustration



GRIDIRON PENDULUM.

in text books of difference in expansion of different metals. Did it ever occur to many of us that the nine-rod pendulum of brass and iron is impracticable, if not impossible? A simple calculation will make this clear. Let L = length of the pendulum from a to b, point of suspension to center of oscillation.

$L = a\,s + h\,s + t\,b$, all iron. Let l = length of brass. The extra length of iron in the pendulum = l also.

If we take the coefficients of iron and brass as 12 and 18 (millionths) we have the equation $12(L + l) = 18l$, the expansion of the iron and brass being equal.

$$l = 2L.$$

This means that the two brass rods on either side must equal in length twice the length of the pendulum, which is of course impossible. If, however, we use 11 and 19 as representing the coefficients of expansion, which is perhaps more nearly the truth,

$$l = 1.4L.$$

The construction of a genuine gridiron pendulum on this supposition is virtually impractical. I wonder how many genuine gridiron pendulums the reader has ever seen.

* School Science and Mathematics.

THE COMMERCIAL USES OF FLUORSPAR.*

By ERNEST F. BURCHARD.

FLUORSPAR or fluorite, chemically calcium fluoride (CaF_2), consists of calcium and fluorine in the proportions of 51.1 to 48.9. The mineral is crystalline, only slightly harder than calcite, and consequently crushes easily. In color the spar ranges, according to purity, from a clear, slightly bluish glasslike substance through various brilliant shades, although much of it is white and opaque. The mineral is usually very pure, the greater part of the material marketed running 98 to 99 per cent, while material carrying less than 95 per cent finds little sale, except at a reduced price. Associated with other minerals, it has a broad distribution geographically and a wide range geologically. The deposits thus far exploited are, however, confined to five States—Arizona, Colorado, Illinois, Kentucky, and Tennessee.

The various uses of fluorspar depend on its chemical composition, fluxing properties, and phosphorescence when heated, and on its optical and gemlike properties. Its preparation involves separation from other minerals with which it is associated, the treatment comprising hand sorting, crushing, and jigging. Part of the high-grade ore is ground and shipped in barrels and sacks; the rest is sold in lump form. Where fluorspar is associated with zinc blende, complete separation of the two minerals has been difficult on account of their nearness in specific gravity. While fluorspar is useful in smelting iron ores it is harmful to zinc, and therefore the zinc-fluorspar concentrates have been of little value. Recently a new process for separating fluorspar and zinc has been reported as successful, which promises to increase the production of both minerals.

The three principal classes of consumers of fluorspar are, in order of importance, smelters and metallurgists, makers of opalescent glass and enameled wares, and chemical manufacturers. The highest grade, "American lump No. 1," which runs less than 1 per cent silica and is white or clear pale blue in color, is sold either ground or in lumps for use in the glass, enameling, and chemical industries, the latter including the manufacture of hydrofluoric acid. Grinding of the pure, clear spar can be dispensed with for some purposes, as it readily decrepitates to a powder when heated. The second grade, "American lump No. 2," is used by blast furnaces in the production of ferro-silicon and ferromanganese, and in basic open-hearth steel furnaces to give increased fluidity to the slag and to reduce the contents of phosphorus and sulphur. This grade includes colored spar and may run as high as 4 per cent silica, though mostly sold with a 3 per cent guaranty. The lowest grade, "gravel spar," including all that contains more than 4 per cent silica, as well as spar mixed with calcite, is used in iron and brass foundries, where it is of value in making the metal more fluid, in permitting the use of greater quantities of lower grades and scrap, and because it carries phosphorus, sulphur, and other impurities into the slag.

Fluorspar has been shown to possess a considerably higher quantitative efficiency as a flux than limestone, especially in smelting refractory ores, but in all metallurgical operations the proportions of the spar that can be used are limited, since its favorable effects do not increase indefinitely as the quantity is increased. In England and on the Continent the use of fluorspar is at present more common than in America, probably because its value has been better understood by European metallurgists. Other minor metallurgical uses are in extraction of aluminium from bauxite, in smelting gold ores, in refining copper, and in refining lead bullion. In the latter process the spar is first converted into hydrofluoric acid. Miscellaneous uses that have been reported are as a bonding for constituents of emery wheels, for carbon electrodes to increase their lighting efficiency while also decreasing the amount of current required, and as a constituent of Portland cement.

A new high-resistance packing manufactured under the Ekert patent by the B. F. Goodrich Company, Akron, O., has a body made of asbestos preserved in its natural fibrous condition and imbedded in pure Para rubber. Owing to the process of manufacture the rubber does not lose its nature, and the asbestos retains its strength under very great pressure. Under test it has resisted a steam pressure of 1,000 pounds, a mechanical pressure of 20,000 pounds, and a superheated steam temperature of 900 deg. F. without injury or deterioration. The packing is made in sheets in two qualities, one for high temperature and ordinary pressure; one for high temperature and high pressure. It is also made in the form of valve disks, gaskets, piston-rod packings, etc., in several qualities calculated to resist the varying demands of different classes of work.

* Abstracted from a bulletin issued by the United States Department of the Interior.

RECENT PROGRESS IN ASTRONOMY.

ADVANCES MADE IN ESTABLISHING AN AUTOBIOGRAPHY OF THE HEAVENS.

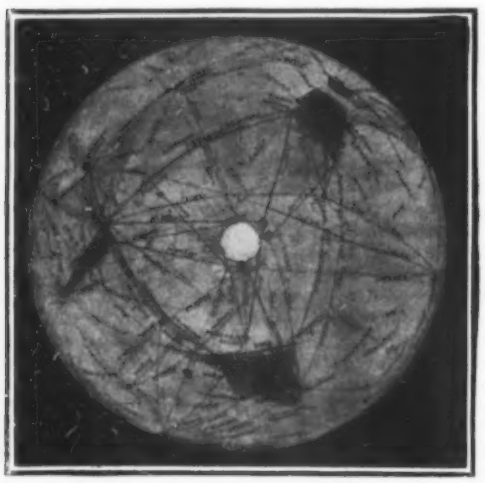
BY PROF. KLEIN.

THE most important advances recently made in astronomy are due chiefly to the construction and use of new and powerful telescopes, spectroscopes and photographic apparatus. The performances of the great refractors of the Lick and Yerkes observatories, so justly admired a few years ago, have been far surpassed by the results obtained by photography with the aid of reflecting telescopes. Especially deserving of mention are the Crossley reflector of the Lick observatory and the 24-inch reflector constructed by Ritchey in 1900 for the Yerkes observatory.

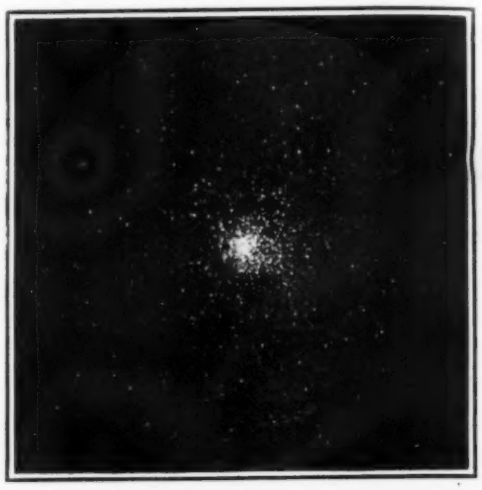
In the latter, perfection has been as nearly attained in the equatorial mounting and mechanism as in the form of the mirror. In favorable atmospheric conditions the image of a star can be kept motionless on the photographic plate for three or four hours. Stars of the seventeenth magnitude, which are barely visible in the 40-inch Yerkes refractor—the largest refracting telescope in existence—can be photographed clearly with the 24-inch Ritchey reflector with an exposure of 45 minutes. The photographs of nebulæ, in particular, reveal details of structure which are not even suggested by the giant reflecting telescopes of Herschel and Rosse or the largest two refractors of the present day. A photograph of the great nebula in Andromeda, taken on September 8, 1901, with an exposure of four hours, shows the spiral structure continued to a small, star-shaped nucleus at the center, a structure not revealed to the eye by any telescope.

Ritchey's experience in the construction of this instrument convinced him of the possibility of making much larger mirrors and setting them in mountings lighter than those of the Lick and Yerkes refractors. He has now completed the construction of a mirror of 5 feet diameter and 25 feet focal length, funds for the mounting of which are being collected.

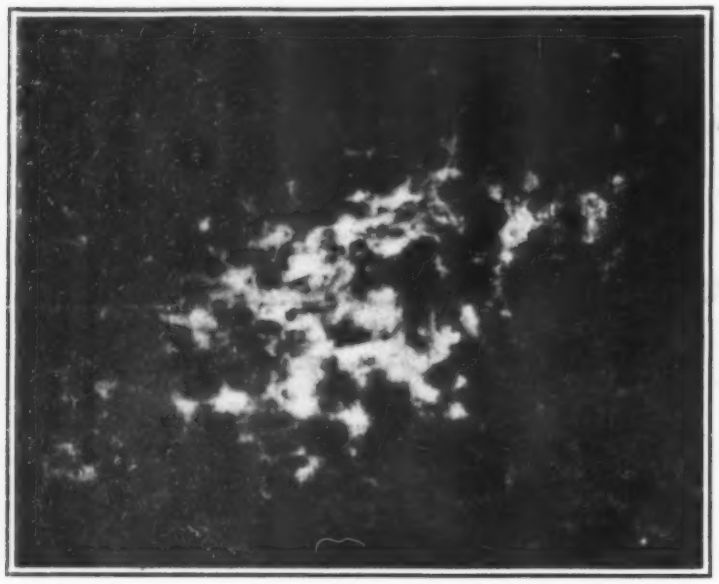
The great double refractor of the Astrophysical Observatory at Potsdam is one of the largest and most perfect of European instruments. The tubes are 12



THE NORTH POLAR CAP OF MARS.

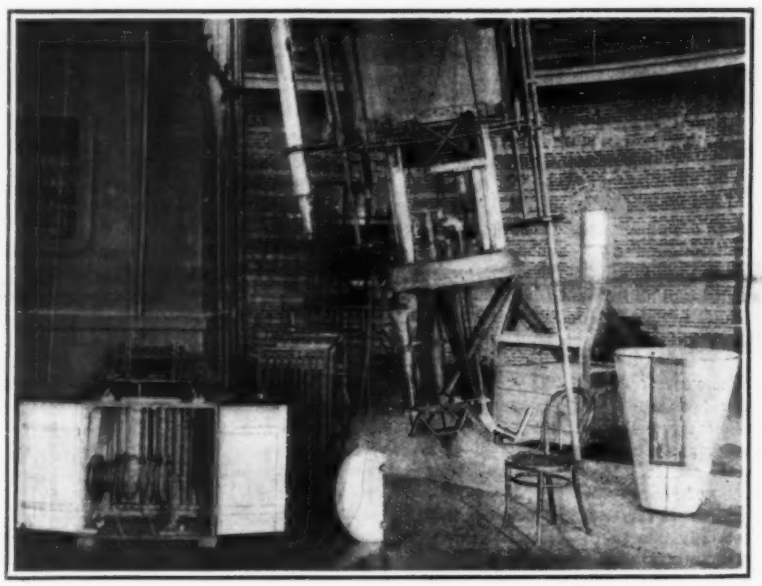


STAR CLUSTER IN PEGASUS.

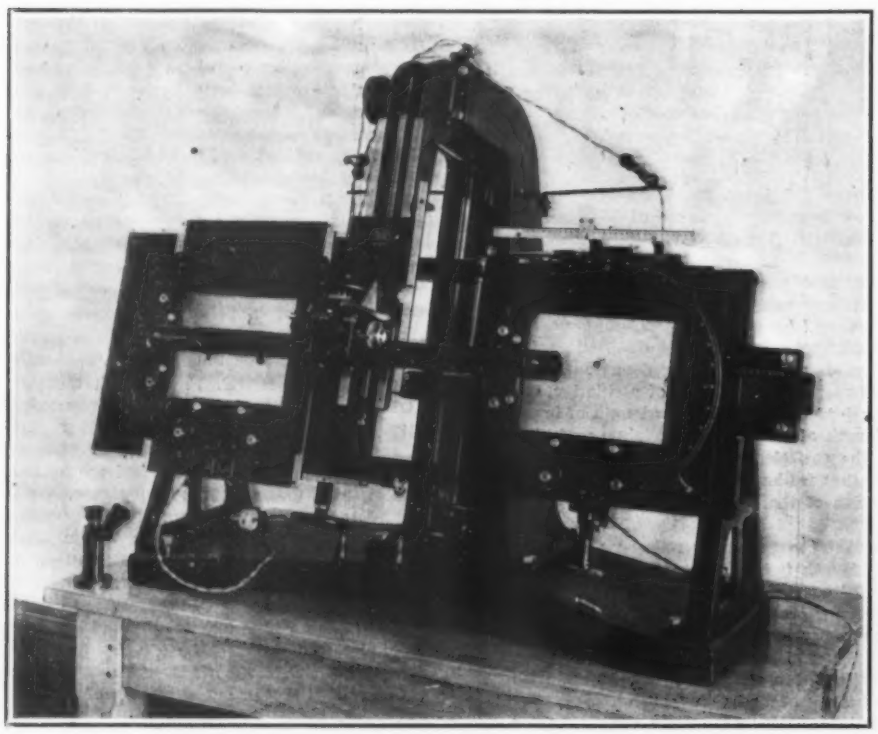


THE GREAT HIGH LEVEL SUNSPOT OF OCTOBER 10, 1903.

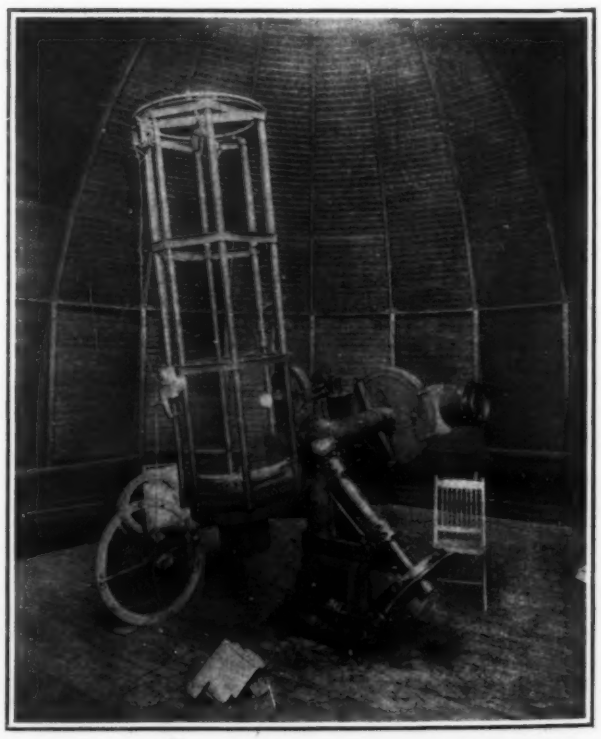
Our insignificant earth would occupy as much space in this sunspot as a pebble in a bucket of water.



THE BRUCE SPECTROGRAPH.



THE STEREOCOMPARATOR OF THE YERKES OBSERVATORY.



THE TWO-FOOT REFLECTOR OF THE YERKES OBSERVATORY.

RECENT PROGRESS IN ASTRONOMY.

meters (39.4 feet) in length. One tube carries an object glass 50 centimeters (19.7 inches) in diameter for eye observation, the other a photographic objective 80 centimeters (31.5 inches) in diameter. The glass disks were cast by Schott & Co., of Jena, and shaped into lenses by Steinheil, of Munich. The moving parts of the instrument weigh 7 tons, and its total weight is 20 tons. The dome is about 70 feet in diameter and 60 feet high and weighs 200 tons. It is turned by an electric motor and can also be moved by hand. The objectives and other lenses cost about $22,000, the mounting $34,000, and the observer's chair with its electric motor $3,000.

A new invention of great value is Prof. Pulfrich's stereocomparator or stereoscopic telemeter. On a massive, inclined metal plate two plate holders are so mounted that they can be turned and moved in any direction by means of fine screws. Two microscopes are so mounted on a fixed arm that two photographs of the same part of the sky, taken at different times, can be examined simultaneously, one with each eye. Slight differences between the pictures thus become very conspicuous, as they produce a stereoscopic effect. Even a planet as remote as Saturn, for example, appears far in front of the background of fixed stars. The same effect is produced when an object appears on only one plate or when one of its images is brighter than the other. In this way Prof. Wolf discovered ten previously unknown variable stars in his first trial of the instrument. The images of an infinitely distant point having been brought into coincidence, those of a nearer object can be made to coincide by moving one of the photographic plates, and the displacement of the plate, measured with scale and micrometer, gives data for the computation of the distance of the object. This method may be applied to the determination of the parallaxes of the fixed stars and it suggests a hope of obtaining an insight into the distribution of even very distant stars and nebulæ through the comparison of photographs made at intervals of many years.

A knowledge of the motion and the physical character of a heavenly body can be obtained by studying its spectrum, or the colored band into which its light is analyzed on traversing a prism. An incandescent gaseous body shows a spectrum consisting of separate bright lines from the number and positions of which the chemical constitution of the glowing gas can be inferred with certainty. An incandescent solid or liquid body surrounded by a cooler gaseous atmosphere shows a continuous colored spectrum crossed by dark lines which reveal, in the same manner, the chemical nature of that atmosphere. If the luminous body is moving toward the observer its spectral lines are slightly shifted toward the violet end of the spectrum, while if it is receding the lines are shifted toward the red end, and the velocity of approach or recession can be determined from the displacement of the lines.

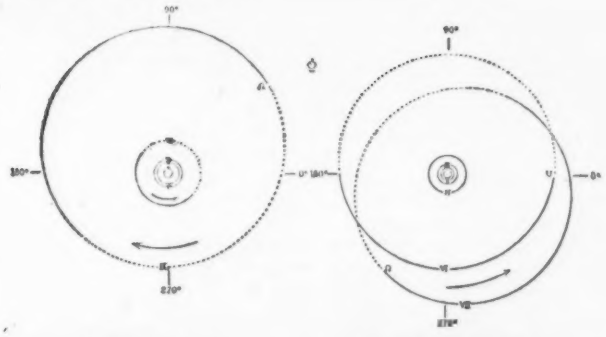
The making of exact spectroscopic measurements with the telescope, however, is a difficult operation. A great advance was made when Prof. Vogel, of Potsdam, succeeded in obtaining accurate and reliable photographs of star spectra, from which the positions and possible displacements of the spectral lines could be determined by appropriate micrometric devices.

MARE IMBRIUM. PLATO.

PART OF THE MILKY WAY.

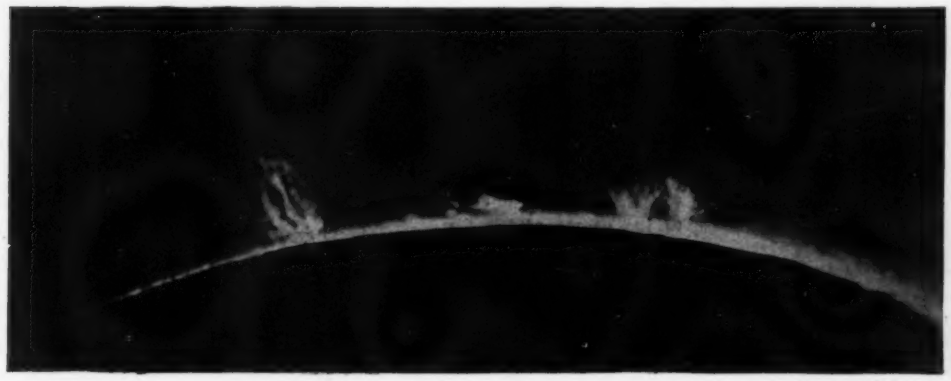
THE SPIRAL NEBULA IN CANES VENATICI.

SYSTEM OF THE DOUBLY DOUBLE STAR CASTOR.



SATURN'S MOONS.

JUPITER'S MOONS.



SOLAR PROMINENCES PHOTOGRAPHED BY LANGLEY DURING THE ECLIPSE OF MAY 28, 1900.

RECENT PROGRESS IN ASTRONOMY.

Vogel's apparatus has been so perfected that the velocity of a star in the line of sight can be determined to within less than 1 kilometer (⅝ mile) per second from measurements of the displacement of lines in the photograph.

In this way many stars have been proved, by the variations in their motions, to be revolving around points comparatively near to them. In other words, such a star is a double star of which one member is invisible. These stars are called spectroscopic double stars and their number appears to be very large, for

THE GREAT NEBULA IN ORION.

One of the first nebulous masses which were spectroscopically examined by Sir William Huggins.

new ones are discovered almost monthly. In many cases the period of revolution is less than one year, in some it is only a few days. In the spectra of a number of other stars, apparently single, the lines are periodically doubled, indicating a periodic mutual displacement of the spectra of two components, both luminous, owing to revolution about their common center of gravity.

The sun is in some respects the most important object of astronomical observation. Yet until within the last half century it was neglected except by a few amateur astronomers who devoted their entire attention to it and especially to the study of sun spots. The methods of solar observation were very crude until the development of spectrum analysis which made it possible to observe continuously certain phenomena which had previously been seen only momentarily at long intervals in solar eclipses.

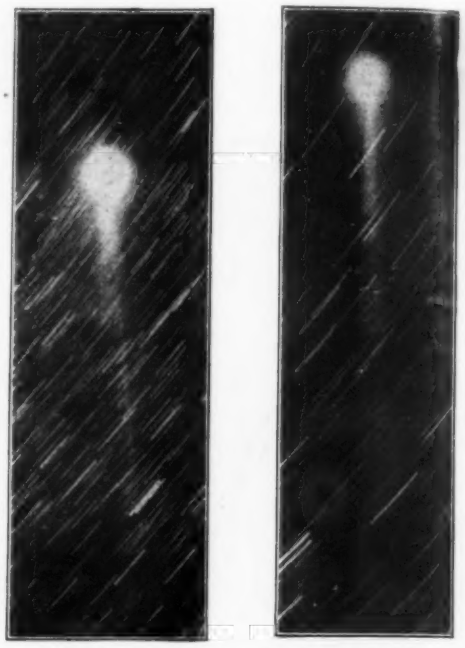
Photographs showing not only the spots and faculæ but also the phenomena of the chromosphere, the protuberances, and eruptions from the sun's interior are now made daily at a number of observatories. A very important advance is due to Hale and Deslandres, who have succeeded in observing, with the aid of a spectroheliograph provided with two movable slits, the movements of masses of incandescent calcium vapor which can be detected neither by the eye nor by the usual photographic methods. At first the masses of glowing calcium vapor appeared to coincide with the well-known faculæ, but they are by no means identical with the latter. Hale has given the name flocculi to these glowing columns of gaseous calcium, hundreds of miles in diameter, which rise above the incandescent vapors which form the photosphere. It is possible even to compare the distribution and size of the flocculi at various levels and it has been found that they become larger as they ascend. For example they are much smaller in a photograph of the great sunspot of October 9, 1903, which shows them bursting from the photosphere, than in a second photograph taken one minute later, when they had reached a higher level. Even the velocity of the ascending vapor has been measured approximately. It is about one kilometer (⅝ mile) per second. For the prosecution of these and other astrophysical researches a great solar observatory, splendidly equipped, has been erected on Mt. Wilson, near Pasadena, Cal.

In regard to the outermost envelope of the sun, the corona, observation is still restricted to the few minutes of totality in solar eclipses, as all attempts to make the corona visible at other times have failed. During total eclipses, however, excellent photographs have been obtained which prove that the corona undergoes characteristic changes in the course of the sunspot period of 11 years. When the spots are fewest the corona consists chiefly of two broad luminous belts parallel to the plane of the sun's equator and shows no rays at the poles, but at the epoch when the spots are most numerous, the coronal rays spring from all parts of the limb of the sun. Many coronas show broad bands of light which are possibly tails of comets near perihelion, for in some photographs of total eclipses unmistakable comets appear near the sun.

Astronomers are not yet in agreement in regard to the physical condition of the sun and the nature of the protuberances, but the theory advanced by Prof. A. Schmidt is rapidly gaining adherents. According to this theory the sun is an incandescent mass of gas, which decreases in density from the center outward, but is not limited by any clearly defined surface. The apparent sharpness of the limb of the sun is an optical illusion due to curvilinear refraction of rays emitted by the inner strata. According to Prof. Julius the protuberances are not real protuberances, but effects of abnormal dispersion of light caused by waves and cyclones in the gaseous mass.

Some progress has recently been made in the study of the mysterious zodiacal light, which appears as a faintly luminous cone in the western sky after sunset in spring and in the east before sunrise in autumn. The very accurate observations of Prof. Wolf indicate that the axis of the zodiacal light lies in the plane of the sun's equator, and Prof. Seeliger has recently shown that the finely divided matter of this nebulous ring is the cause of some hitherto inexplicable anomalies in the motions of Mercury.

Many photographic studies of the irregularities of the moon's surface have been made within the last decade. The first systematic research was begun by the Lick observatory, with its great refractor, but was interrupted by lack of funds. Then the Paris observatory undertook the construction of a lunar atlas on a large scale. Fifty plates have already been made and reproduced admirably by photogravure. Meanwhile, Prof. William Pickering had compiled, by exceedingly diligent work in Jamaica, a photographic atlas covering the entire surface of the moon and comprising eighty plates. Each lunar region is shown under five different conditions of illumination, namely: immediately after sunrise, in the middle of the (lunar) morning, at noon, in the afternoon, and just before sunset. The photographs are thus peculiarly valuable for the study of the lunar formations, for these vary greatly in appearance according to the height of the sun above the lunar horizon. Some of them are recognizable only at sunrise and sunset, and many are nearly or quite invisible, because of the absence of shadows, when the sun is high. Photographs on a still larger scale, but as yet of only a few lunar regions, have been made with the great telescope of



Borelli's comet, July 15, 1903. 2 hours, 16 minutes' exposure.

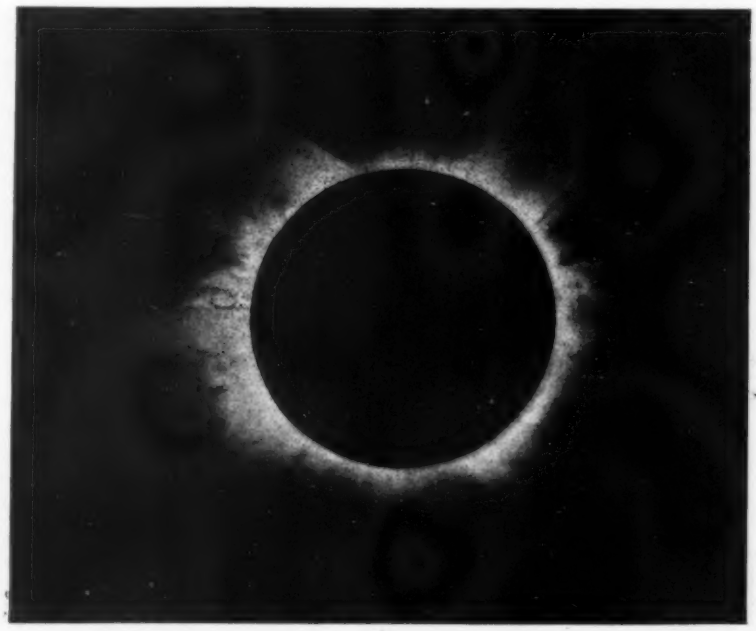
Borelli's comet, July 20, 1906. Four hours' exposure.

LICK OBSERVATORY PHOTOGRAPHS OF BORELLI'S COMET.

Stars appear as lines, because the motion of the comet was followed by the telescope.

the Yerkes observatory. These are by far the best lunar photographs in existence, yet they show no more detail than can be seen with a telescope of 3½ inches aperture. Their peculiar value, however, resides in the fact that they are perfect representatives of the moon's surface and will enable future observers to determine whether or not any change has taken place. The only changes yet detected are in a depression near the crater Hyginus, in some small formations near Linnæus, and in some still smaller objects.

Of the planets, Mars continues to attract the greatest attention. Prof. Percival Lowell has made an elaborate study of the planet with a large telescope mounted in a special observatory in the rare, pure air of Flagstaff, Arizona. He has confirmed Schiaparelli's discovery of the temporary doubling of the canals and observed many other remarkable changes. For example, certain canals were very distinct during several oppositions, then disappeared and remained in-



THE TOTAL ECLIPSE OF AUGUST 9, 1896, PHOTOGRAPHED BY BADEN-POWELL.

RECENT PROGRESS IN ASTRONOMY.

visible for several Martian years and finally reappeared exactly in their former configuration. According to Lowell, this elusive behavior can not be explained by either optical or seasonal conditions, for these abnormal canals were surrounded by other canals which underwent seasonal changes with perfect

regularity. Very close and careful study of a number of canals led Lowell to the conclusion that their changes could not be explained by natural causes, but must be due to the efforts of the inhabitants of Mars to divert a portion of the scanty water supply from one region to another. In regard to the seasonal changes of the majority of the canals, he found that their development was progressive, beginning at the northern polar zone and continuing beyond the equator, in accordance with the advance of the season and the melting of the north polar ice cap. This suggests that water affects the visibility of the canals, not directly, but indirectly by promoting the growth of vegetation along their banks—these broad belts of vegetation, indeed, being what we see and call canals.

Prof. William Pickering has also been observing Mars for years with powerful telescopes, including Lowell's. In a recently published account of his work, he maintains a rather skeptical attitude in regard to the systematic doubling of the canals, a matter which, in his opinion, requires further investigation. He concedes that the existence of numerous fine straight canals, of which several often meet in a common point, and which in their totality present a very artificial appearance, affords an argument in favor of the presence of intelligent beings on Mars, but avoids expressing a positive opinion on the subject.

The small planets or asteroids between the orbits of Mars and Jupiter, the first of which, Ceres, was discovered by chance on the first night of the nineteenth century, have been systematically hunted, with telescope and chart, by various astronomers since the middle of that century. About 500 asteroids were discovered by this laborious method for which Prof. Wolf has lately substituted photography. In Wolf's method a very long exposure is made during which the telescope is caused to follow accurately the diurnal motion of the heavens. On the plate the fixed stars appear as dots but any planetoid that may be in the field of view traces a short line in consequence of its proper motion. J. H. Metcalf has recently reversed the process. The average apparent hourly motion of the planetoids is 34 seconds of arc. Hence, if the telescope is caused to turn with this angular velocity, the planetoids appear as dots, more or less sharp, and the fixed stars as lines. Both methods have proved very effective and in the single year 1906 nearly 100 new asteroids were discovered by their aid. Most of these are very faint and many are invisible except with the largest telescopes. Eros, discovered in 1898, and No. 588, discovered by Wolf in 1906, are of very great astronomical interest—the former because the semi-major axis of its orbit, or its mean distance from the sun, is less than that of Mars, and the latter because its mean distance is greater than Jupiter's. The orbits of both little planets, therefore, transcend the zone bounded by the orbits of Mars and Jupiter, to which all the planetoids were supposed to be confined. As Eros occasionally approaches the earth more nearly than Mars it offers a very welcome means of obtaining the solar parallax to a greater degree of approximation.

No fewer than five exceedingly faint and previously unknown satellites of Jupiter and Saturn have been discovered within the last fifteen years. The four well-known moons of Jupiter were discovered by Galileo in 1610. Seven satellites of Saturn were discovered between 1655 and 1789 and an eighth (by Bond of Cambridge) in 1848. In 1892 Barnard, using the great Lick refractor, discovered a fifth satellite of Jupiter, close to the planet, around which it revolves in 12 hours. Although the new satellite was very faint it showed so clearly on the photographic plate that a systematic photographic search for other satellites of Jupiter and Saturn was made with the Crossley reflector. Simultaneously the branch observatory of Harvard at Arequipa, Peru, undertook a similar search with a 24-inch photographic refractor. The first success was obtained at Arequipa, in 1899, in the discovery of a very faint ninth satellite of Saturn. The Lick Observatory followed with the discovery of a sixth and a seventh satellite of Jupiter in December, 1904, and January, 1905, and a tenth moon of Saturn was discovered in April, 1905, by the astronomers at Arequipa.

The orbits of the sixth and seventh satellites of Jupiter lie far outside of those of the other five, and are greatly inclined to the planes of the other satellites. They are also nearly coincident, very eccentric and intersect each other so that a collision between the two newly found satellites is by no means impossible.

Phœbe, the satellite of Saturn, discovered by Pickering in 1899, is so distant from the planet that its period of revolution is 550 days, but its most remarkable peculiarity is its retrograde motion, opposite to those of the other satellites and the solar system in general. The period of revolution (21 days) and the mean distance from Saturn of the satellite discovered in 1905 are almost identical with those of Hyperion, discovered by Bond in 1848, but the orbit of the new satellite is so eccentric that it crosses those of two others in addition to Hyperion. Its diameter is estimated as not more than 40 miles.

Photography has also contributed very important additions to our knowledge of comets within recent years. It gives more accurate pictures of the tails of comets than can be obtained by ocular observation and hand drawing, and therefore makes it possible to calculate the paths of the particles of matter of which the tails are composed. Especially fine photographs have been made at the Lick and Yerkes observatories. The moving mechanism of the telescope was adjusted to make the image of the comet motionless on the plate, hence the images of stars appear elongated.

Photographs of Swift's comet taken on May 6, 1899, at the Lick Observatory show the head apparently rotating about an axis passing through the sun and the strands of the tail twisted together. A photograph made on May 8 shows a greater distance between the head and the twisted portion but the twist had not wholly vanished on the following night. In a photograph of June 9 the nebulous mass surrounding the head appears elliptical as if about to throw out a new tail, and two rudimentary tails appear in the photograph taken on the following night.

Borelli's comet of 1903 was photographed by Barnard at the Yerkes Observatory. To the naked eye the tail of this comet was very faintly visible to a distance of only 4 degrees from the head, but the photographs showed a tail 17 degrees in length. A photograph taken on July 24 revealed a phenomenon never before observed with certainty. The tail was suddenly cut off at a distance of 2 or 3 degrees from the head, the severed portion being left behind but remaining parallel with the rest. No trace of the occurrence appeared in the plates exposed on the preceding and following nights. The phenomenon, therefore, must have been confined to a few hours. The discontinuity in the tail appears also in a photograph made by Quénisset at the private observatory of Nanterre, France, on the night of July 24 to 25. From a comparison of the two photographs Barnard calculated that the matter of the tail was receding from the head with a velocity of 16.2 kilometers (10 miles) per second. According to Prof. Barnard, the parting of the tail was caused by a sudden change in the direction in which the stream of matter forming the tail was projected from the nucleus. Before the matter was expelled from the nucleus it was approaching the sun with the velocity of 35.2 kilometers (21.9 miles) per second, but after expulsion this velocity was gradually reduced to zero, and thereafter the cometary matter receded from the sun. The reversal of motion indicates repulsion by the sun. From photographs of the comet 1903 IV made at various observatories Jaegermann found that during a period of seven hours part of the matter of the tail moved with a velocity of 35 kilometers (21.75 miles) per second along an arc convex toward the sun, and at the same time receded from the sun at the rate of 17.2 kilometers (10.7 miles) per second.

An explanation of these motions is given by Prof. Bredichin's mechanical theory of cometary phenomena. This theory assumes that the tails and the emanations from the nuclei of comets are composed of ponderable matter in a state of molecular or even atomic attenuation which is attracted or repelled by the sun, with varying degrees of force, according to its chemical nature. The tails of all comets that have been observed may be divided into three types. In the first type the repelling force of the sun is 18 times the attracting force, in the second type the repulsion varies from 0.5 to 2.2 times, in the third type from 0.1 to 0.3 times the normal attraction. The initial velocities with which the particles start from the nucleus toward the sun range from 3 to 10 kilometers (1.9 to 6.2 miles) per second in the first type, from 0.9 to 2 kilometers (0.6 to 1.25 miles) in the second type, and from 0.3 to 0.6 kilometer (0.2 to 0.4 mile) in the third type. Bredichin concludes that the tails of the first type are composed of the lightest element, hydrogen, those of the second of hydrocarbons, sodium, etc., and those of the third of heavy elements, such as iron. Bredichin's theory has not yet been fully confirmed but at least it is not contradicted by the evidence of the spectroscope.

For many years a continuous and systematic photographic survey of the heavens has been carried on by the Harvard observatory at Cambridge and its branch at Arequipa, Peru. Nearly 100,000 photographs have been made which show the positions and relative brightness of all stars of the 11th magnitude, and the spectra of bright stars for every year since 1890. This record, written by the stars themselves, constitutes an authentic and accurate autobiography of the sky. When any supposedly new discovery is made the archives of Cambridge will show whether the object was visible in 1890 and how it has comported itself since. Refracting telescopes have hitherto been employed in this work but a large reflecting telescope, recently completed, will penetrate far more deeply into space and focus on the photographic plate rays that may have occupied thousands of years in coming from the stars whose images they trace.

Photographs of star spectra have already led to important results in the case of ordinary double stars, that is, stars visible as double stars in the telescope. An example is afforded by a star of the fourth magnitude in the constellation Equulus which Struve, in 1852, discovered to consist of two stars nearly equal in brightness. Later observations showed that these stars revolve about their common center of gravity in elliptical orbits, the period of revolution being between 5 and 7 years and the greatest diameter of the relative orbit, as seen from the earth, covering an arc of 0.56 second. The twin spectra of this double star, which have been photographed many times at the Lick observatory, show a periodic relative displacement of the dark lines. The period of this phenomenon is also 5 to 7 years, and the relative velocity of the two components at the epoch of their nearest approach to each other is found, from the amount of displacement of the lines, to be 20.5 kilometers (12.75 miles) per second. From this velocity and the period of revolution the greatest diameter of the orbit is reckoned to be 373 million miles. As this diameter subtends an angle of 0.56 second at the distance of the earth, that distance must be 284 million million miles, so that the light of the star occupies some fifty years in the journey. The aggregate mass of the two components is found to be 1.9 times the mass of the sun and both give spectra almost identical with that of the sun.

Of the numerous spectroscopic doubles, or stars attended by invisible companions whose existence is inferred from spectroscopic evidence, one of the most interesting is Castor in the constellation Gemini, which is resolved by even a small telescope into two stars separated by an interval of six seconds, which fluctuate in brightness from the second and third magnitudes to the seventh. From a comparison of recorded observations, beginning with 1718, it appears that the smaller or companion star revolves about the principal star once in about 350 years. Belopolsky discovered that the companion is itself a spectroscopic double which revolves with its invisible satellite around their common center of gravity once in three days and spectrographs made at the Lick Observatory prove that the principal star is also a spectroscopic double, although its period of revolution has not yet been determined.

Photography has achieved remarkable triumphs in the investigation of variable stars, the brightness of which fluctuates periodically or irregularly. The number of such stars is far greater than was formerly supposed. Within recent years the variable character of hundreds of stars has been established by photographic methods. Indeed, there are star clusters, smaller than the moon's disk, containing hundreds of variable stars, many of which complete their cycle of changes in less than 24 hours. Photographs of the spectra of a number of variable stars prove that these stars, also, are spectroscopic doubles, the fluctuation in brightness being due to eclipses by a dark companion or mutual eclipses of two bright components revolving around each other.

The known number of new stars (Novæ) has likewise been increased by the photographic survey of the heavens. The new star in Perseus opened the twentieth century with great brilliancy. It attained its maximum brightness, that of the second magnitude, in February, 1901, and thenceforth diminished in brilliancy rapidly though not uniformly, while its color, originally blue-white, became yellow and finally red. In April, 1902, it had dwindled to the tenth, and it sank later to the twelfth magnitude. Photographs made by Wolf and by Ritchey show the star surrounded by a spiral nebula which rapidly increased in size, parts of it undergoing in the course of a few days displacements that indicated a motion with the velocity of light. The spectrum of the star was at first continuous, without either dark or bright lines. Subsequently dark bands appeared, then bright bands and finally, when the star had become very faint, its spectrum consisted only of a few bright lines identical with those of nebulæ. The best explanation of the sudden appearance and gradual wane of the new star is that of Prof. Von Seeliger, who assumes that the surface of a previously dark body was heated to luminescence by collision with a nebula or mass of cosmical dust. As the rays of the now luminous star penetrated the nebulous envelope this became faintly visible, the illumination necessarily progressing with the velocity of light. If this assumption is true the distance of the star from the earth can be calculated from the rate of increase of the apparent size of the nebula. The result is more than 900 million million miles, a distance which it would take light 161 years to traverse. Hence the phenomenon which we saw in 1901, really occurred in 1740.

Star clusters and nebulæ are now studied almost entirely by photographic methods, as even small photographic telescopes are more fruitful in results than direct observation with large refractors. The photographs prove that the drawings of star clusters and nebulæ, with few exceptions, are very incorrect and

that nebulæ are far more numerous than had been supposed. Some 8,000 nebulæ were recorded by the two Herschels, Lord Rosse, and D'Arrests. In 1904 Perrine examined photographs of various regions of the sky made with the Crossley reflector and found an average of eight nebulæ on each plate. As 62,000 plates would be required to cover the whole sky it follows that the total number of nebulæ must be about 500,000.

By employing longer exposures and more sensitive plates the number would doubtless be increased to a million. The number of stars that can be photographed is estimated at 100 millions. The photographs of Prof. Wolf of Heidelberg give important information of the number and distribution of nebulæ. Wolf divides nebulæ into three great groups; regularly formed, irregularly formed, and very large structureless nebulæ. The variety in the configuration of nebulæ is almost endless.

Very peculiar are the nebulous chains, discovered by Wolf, which extend in long straight or curved lines from stars and nebulæ and often terminate in other stars and nebulæ. These objects present a wonderful appearance in the sterocomparator and in some cases the chains extend over many photographic plates and cover vast regions of the sky with their network. Another important fact discovered by Wolf is that some of the most conspicuous nebulæ are surrounded by starless zones though the area of the nebula itself contains more than an average number of stars.

Photographs of the larger star clusters and nebulæ, especially the photographs made by Roberts, and at the Harvard Observatory, show the great variety and complexity of these heavenly objects. The spiral character of the great nebula in Andromeda was first revealed by Roberts's photographs. The photographs made by Prof. Keeler with the Crossley reflector of the Lick Observatory proved that many of the newly discovered as well as the well known nebulæ are of similar structure. Keeler concluded that the spiral is the normal form of compact isolated nebulæ. The very large faint nebulæ, like that of Orion, show little tendency to spiral arrangement. The best photographs of the great nebula in Orion are those made at the Harvard Observatory. Prof. Hartmann of the astrophysical observatory at Potsdam has made an excellent photograph of this nebula, using only the rays of the line λ 3727 in the ultraviolet part of its spectrum. This photograph shows the nebula larger than it appears when viewed directly. This nebula probably consists of hydrogen surrounded by one or two unknown gases.

Of the great star clusters like those of Hercules and Centaurus photography has given the only representations that will be of value to future astronomers.

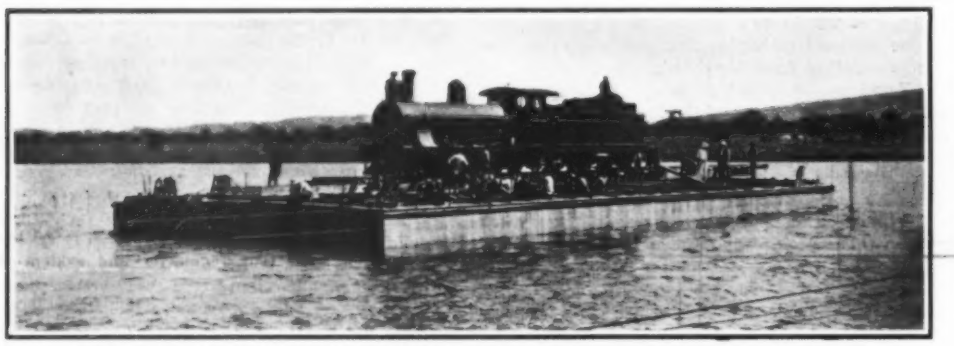
Finally, the photographs of the Milky Way, first obtained by Barnard in 1899, reveal a great variety of nebulæ and star clusters, separated by dark tortuous canals, indicating a structure of amazing intricacy and beauty. Astronomers are still at variance in regard to the part played by the Milky Way in the economy of the universe, but we may hope that the twentieth century will bring some knowledge of this largest of heavenly objects.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Die Illustrirte Zeitung.

THE KAFUE RIVER BRIDGE ON THE CAPE TO CAIRO RAILROAD.

THE LONGEST IN AFRICA.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

A NOTEWORTHY engineering achievement, which considering the conditions prevailing is of more than passing interest, has recently been successfully completed on the extension of the Cape to Cairo railroad through northwestern Rhodesia toward the frontier of the Congo Free State. This is the spanning of the Kafue River at practically its widest part by a magnificent steel bridge, which ranks second in importance and dimensions to that built across the Zambesi gorge just below the Victoria Falls. Whereas the latter is the highest bridge in Africa, that just thrown across the more northerly waterway ranks as the longest bridge in the dark continent. The Kafue River is one of the most important tributaries to the Zambesi, rising on the Congo frontier, and after a meandering course through northwestern Rhodesia empties its waters into the Zambesi about 100 miles below the Victoria Falls. At the point of crossing, the waterway is over 1,300 feet in width, flanked on either side by lowlying ground. The maximum depth of the river in the dry season is only about 9 feet, rising to 17 feet in the wet period, and the current has a maximum flow of only some three miles per hour.



THE PONTOON, USED IN TRANSPORTING SPANS, FERRYING AN 80-TON LOCOMOTIVE ACROSS THE KAFUE RIVER.

The erection of this bridge was carried out by the contractors, Messrs. Pauling & Co., Limited, of London, from the designs of Sir Charles Metcalfe and Sir Douglas Fox & Partners. The method adopted for erecting the structure was of an interesting nature.

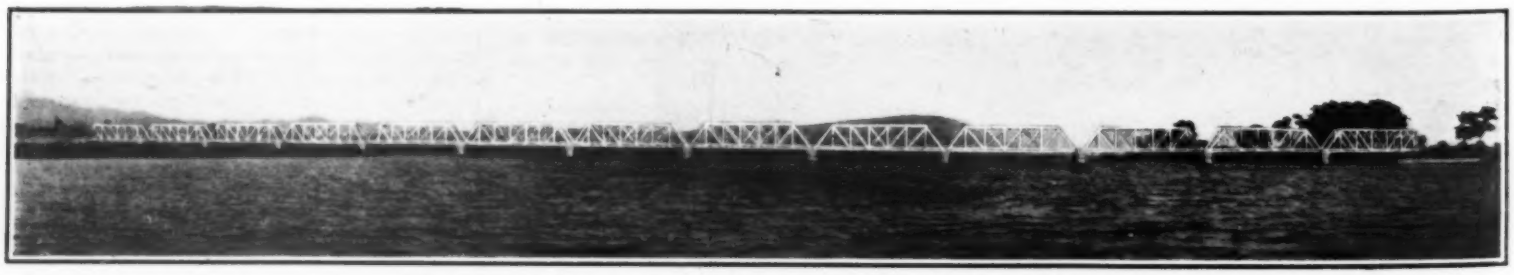
When the railhead has reached a point about 180 miles distant from the southern bank, the preliminary preparations for constructing the bridge were hurried forward, for the purpose of saving time as much as possible, so that when at last the river was gained, the transportation of material across the waterway for the continuation northward would not be delayed. Animal transport comprising mules and oxen and wagons was employed for the conveyance of the requisite plant, timber, tools, cement, and other such materials to the site of the temporary erecting yard on the river bank. Of course, as the railhead advanced, the length of this intervening distance was decreased, until at last the animals worked over some 20 miles only. For a distance of some 60 miles below the south bank an area of unstable soil was encountered, which presented many perplexing difficulties, both in regard to the animal transportation and the building of the track.

The bridge is of the open-lattice girder type, the design being made as light as practicable in order to facilitate transport. There are thirteen spans, each of 100 feet, and the total length of the bridge over the bank abutments is 1,400 feet. The steelwork was prepared in England and dispatched in pieces to the erecting yard on the south bank of the river ready for riveting up, since it was found impossible to dispatch the bridge spans in sections to the site. The erecting yard was equipped with a complete power plant, comprising a 40-horse-power engine, steam being supplied from a battery of three boilers. This plant supplied all the requisite energy for working the pontoon by means of which the bridge was erected, generated the electricity for the lighting equipment, and also provided the power for the pneumatic riveting and pumping machinery. The supporting piers in the river, together with the bank abutments, are constructed of concrete. It was calculated that the spans would be ready for placing in position by the time the river was in full flood, so that the falling water might be utilized to assist the work. The piers were therefore commenced when the waterway was at its lowest level. Fortunately, the river bed was found to be of hard rock and gravel, which offered a solid foundation for the piers. The piers each measure 18 feet in width by 8 feet in thickness. Cutwaters are provided on the upstream side. When the river is in flood, there is a space of 4 feet between the water level and the under surface of the bottom main girders. With this river there is moreover a complete absence of scouring action by the current, which feature combined with the rocky nature of the river bed disperses any apprehensions as to the piers becoming undermined.

The pontoon which was utilized for the conveyance of the spans from the shore yard to their respective sites measures 95 feet in length by 45 feet beam. It was of great service in handling the material across the river for the northward continuation of the line while the bridge was being built. An endless wire cable was passed across the river, and carried round a drum on the north bank driven by a 24-horse-power winding engine stationed on the south bank, by means of which the pontoon was hauled from one side to the other as desired.

The pneumatic riveting was entirely carried out by white labor, of which there was a fair supply available, assisted by gangs of natives. The spans are each 100 feet in length by 14 feet wide, about 20 feet in height, and weigh complete 56 tons each, giving an aggregate of 728 tons of steelwork for the whole structure, which considering its great dimensions is by no means heavy, though possessing an ample factor of strength. When the spans were all completed in the erecting yard, the masonry piers were completed, and at this juncture the river was in full flood.

Novel means were adopted for the transshipment of the spans from the erecting yard to the deck of the pontoon. The latter was moored end on to the river bank, centrally opposite the railroad track, which was then continued along the deck of the pontoon. On shore two short lengths of track were also laid down at right angles to the main track at either end of the spans and passing beneath them. These transverse tracks were well greased, so as to become launching ways with the lowest trusses of the spans resting upon them. A large gang of natives were then detailed to each end of the span, and with the aid of treble purchase blocks fixed on the opposite side of the main line, by sheer physical effort hauled the span along the short transverse rails broadside on to the main track metals leading to the deck of the pontoon.



THE KAFUE RIVER BRIDGE ON THE CAPE TO CAIRO RAILROAD.

The longest bridge in Africa. Total length over bank abutments, 1,400 feet. The river is in full flood.

This track was also thoroughly lubricated, two locomotives brought up against the rear end of the span, and then it was slowly forced forward on to the deck of the pontoon, where it was firmly lashed in position.

The pontoon loaded with the span was now hauled out into the river by the endless cable and winding engine until directly between the two piers upon which the span was to be deposited. The rope was then slackened, and the pontoon allowed to drift downstream with the current. Steering was effected by hawsers running from the ends of the pontoon and made fast to the two piers between which the pontoon was to drift, warping right or left being carried out by gangs of natives hauling the pontoon end of the ropes. In this way the pontoon was brought to the required point between the two piers, an operation which required careful manipulation, seeing that there was only a clearance of 2 feet 6 inches at either end, and was then moored. The span was slightly raised by means of hydraulic jacks, and then slowly lowered into position upon the roller bearings on the piers. The pontoon was hauled clear of the piers by the tightening of the cable, and the span was thus left *in situ*. This operation was repeated with each span, and proved so expeditious and simple, that the whole of the thirteen spans were transferred from the erecting yard and anchored upon the piers within the space of eight days, which was but half of the estimated period of the engineer for accomplishing this task.

The bridge is intended exclusively for railroad traffic, and only a single line is laid. The total cost of the structure including setting in position has amounted to approximately $250,000. The exact time occupied in assembling, riveting, launching, and setting the steelwork in position was from January 19 to June 30 of last year.

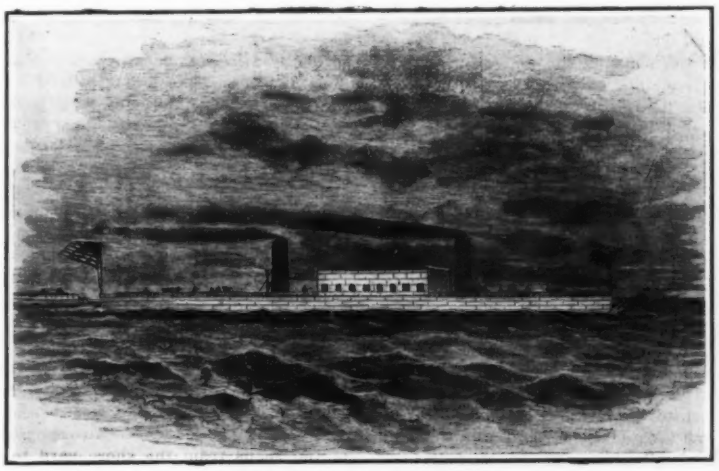
THE DEVELOPMENT OF ARMORED WAR VESSELS.—V.

ARMOR PLATING IN THE UNITED STATES.

BY J. H. MORRISON.

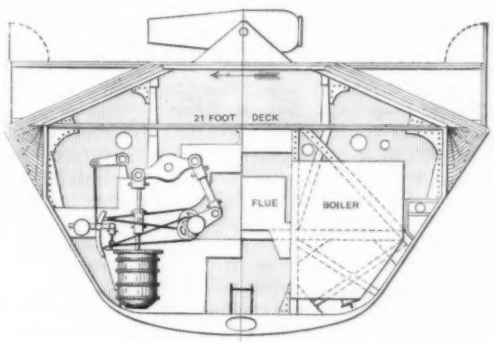
Continued from Supplement No. 1655, page 179.

IT is now seen what mechanical difficulties the contractor had to encounter, what vital interests to overcome, and the surrounding conditions in general at the beginning of the contract. He certainly had a great deal of confidence in his ability to perform his part of the contract, or he would not have made the outlay for a drydock and plant, to prosecute the work, at his own cost; and this was a sum of no small amount at the time. He undoubtedly knew what difficulties he must surmount in the beginning, but he could hardly have foreseen such rapid and radical improvements in almost every department of a naval steam vessel as were made in a few years.



THE STEVENS BATTERY.

From the official records of the Navy Department, there is found that on the expiration of the two years' time limit in the original contract, "nothing appears to have been done; no plan was furnished; the construction of the iron war steamer was not commenced. The contract was renewed on November 14, 1844. Some preparation was made under the second contract, and a portion of the material was procured, but no plan was submitted by the contractor; the Secretary of the Navy withheld all payments after December, 1845." Thus the matter rested until December, 1848, when a third contract was made with Mr. Stevens and four years' time limit from that date given for the completion of the contract. "No precise plan has yet been submitted by the contractor to the department, and no plan has been made in the construction of the vessel beyond the purchase and delivery of certain quantities of iron." At this time there was an unexpended balance of the appropriation of $183,521.22, showing an advance by the government on the contract to December, 1849, on manufactured and unmanufactured material of $66,478.78. In the contract of November, 1844, there was a provision that "a scale of prices for labor, the use of tools and machinery, also the percentage to be advanced on unwrought material, should be furnished." The advance of 33 1-3 per cent was agreed upon. The Navy Department had a representative on the ground, and it was on his certificate that payments were made to the contractor. This "masterly inactivity" dragged along for two years longer, and the patience of the Navy Department officials with the contractor seemed to be near an end. The Secretary now considered the contract to have been abandoned by Mr. Stevens, and he directed that certain material that had been purchased with government funds for the vessel should be sold; but at the request of the contractor the order was suspended until the case had been submitted to Congress for their decision. The subject was presented to that legislative body in the session of 1851-52, and after being thoroughly discussed the unexpended part of the appropriation, that had been carried to the surplus fund a short time before, was restored to use again under the contract, by an act of August 31, 1852. Ex-



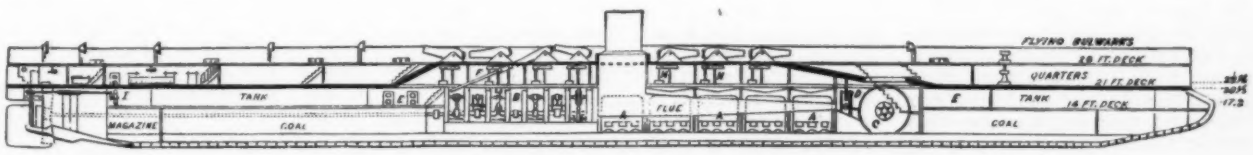
CROSS SECTION OF THE STEVENS BATTERY

Commodore R. F. Stockton, U. S. N., and Stephen R. Mallory, who was Secretary of the Navy of the Confederate States at a later period, were members of the Naval Committee of the Senate at the time, and prominent members of that body in advocating the completion of the vessel.

One item of contention appears to have been that there was not a proper recognition by the contractor of the Bureau of Construction of the Navy Department, by the filing of a plan of the proposed vessel with the department, as provided for in the original contract. This was the first opposition in the construction of iron and wooden vessels in the navy. There was also a wide difference of opinion as to the vessel being shot and shell proof. The Navy Department contended that it should be against the improved guns in use under the law of 1852, and this was subsequently agreed to.

The causes that produced the delay in the erection of the vessel in the drydock are set forth by the contractor: "That during the period of delay he was employed in making extensive and expensive experiments at his own cost, to ascertain whether the principles upon which he intended to proceed were beyond all kind of doubt, practical as well as new, and irresistible." These causes of delay are also clearly set forth in the "Morton Memorial of Stevens Institute of Technology, 1905," by Prof. F. DeR. Furman, in a letter of Edwin A. Stevens to the Secretary of the Navy in December, 1856, where he says in part: "The different views taken from time to time by the officers of the government upon the subject, and the direction given for the suspension of the work, of necessity prevented its execution with that regularity and system that might otherwise have been secured. This may not, however, prove ultimately disadvantageous to the United States, for the reasons which I am about to state, and in stating which I shall in a great degree explain the unanticipated increase of cost. Vast changes have taken place, both in the size of vessels of war and the weight of their armament, since the year 1842. Paixhan guns of 64 pounds were the heaviest metal then used in the navy. Now, solid shot of 172 pounds are not unfrequent. The sizes of the vessels themselves have correspondingly increased.

"While, therefore, the size and strength of the battery were amply sufficient to resist the character of the vessels and arms then in use, they might prove an insufficient defense against the larger vessels and heavier guns which were rapidly being introduced into the navies of all the great powers. These changes manifestly rendered necessary corresponding alterations in the size and strength of the battery, without, however, in any respect changing the principles of construction (were by letter communicated to the department by Mr. Stevens), and to this cause is to be referred the increased cost of the battery. It could have been completed for the price named in the contract, and delivered to the government, but under the changed condition of the navies of the maritime powers it would have been comparatively useless, and it would have been unworthy the well-earned character of the contractor, who never sought profit from his country's government, to have done so. The battery required to be correspondingly enlarged and strengthened; it would protect against steam vessels of great size and speed, and the power of her engines required to be correspondingly increased. She must carry a heavier armament to meet upon a footing of something like equality those of other nations, and must therefore be larger to carry it. She must resist effectually the vastly increased weight and power of the guns newly introduced, and must therefore be strengthened accordingly."



INTERIOR ARRANGEMENT OF THE STEVENS BATTERY.

The contract was again in force through the act of

August 31, 1852, though no work of erection appears to have been done for some time, as by the report of the Bureau of Construction of December, 1853, it is found, "instructions were given in January last to proceed with his contract, since which the sum of $34,794.64 has been paid him for the purchase of materials, but no evidence has been received of his having commenced operations on the work."

The contractor was now convinced that a radically different class of vessel must be constructed to comply with the demand of the later decision on the subject, from that originally planned. It took many months to work out a design that it was believed would fill the requirements of the law. This was for a much larger vessel, with greater power for propulsion, and having greater armor protection. It was not until July, 1854, that the first frame of this vessel was erected in the drydock. In preparation for building this larger vessel, the drydock had to be extended by cutting a tunnel about one hundred feet long into a side hill to permit the erection of the fore body of the vessel.

The erection of the vessel having assumed some form in the drydock, the Secretary of the Navy in his annual report in 1854 said: "Mr. Robert L. Stevens is now rapidly progressing in the construction of the iron war steamer, . . . that the boilers will be ready to put on board in about three weeks, and the shafts, beams, cranks, and links are nearly finished and turned, and that he has nearly 500 men engaged on the work." As there was something now to show for the money expended by the Navy Department on the vessel, and Congress being very liberal at this time in the disposition of the funds in the U. S. Treasury, appropriated a further sum of $250,000 on March 3, 1855, for the completion of the vessel. The further progress of the vessel is mentioned in the next report of the Secretary of the Navy: "The iron war steamer building by Mr. Stevens has made much progress." A few months later Mr. Robert L. Stevens died, on April 20, 1856, soon after which the further construction of the vessel ceased, and but little was done in that direction by his brother Edwin A. Stevens, who came into possession of the property after his brother's death, up to the opening of our civil war.

In 1861 Edwin A. Stevens laid before the Navy Department a plan for the completion of the vessel, and a board of naval officers was appointed by the Navy Department to examine the vessel as it lay in the dry dock at Hoboken, N. J. They reported on January 2, 1862, the result of their examination of the vessel, and the proposed plans for its completion as a vessel of war. It was a very elaborate report, much in detail, and showed how far the vessel had progressed at the time, and what were the latest improvements in a vessel of that type. The report is in part: "The shell of the vessel is nearly completed up to a height of 31 feet from the bottom, but without the decks, or the beams upon which they are to rest. The vessel is 420 feet long by 45 feet extreme breadth. The iron plating, with the exception of a keel plate which is 10 inches wide and 1 inch thick, and the garboard strakes which are 30 inches and ⅝ inch thick, is ½ inch thick, riveted to ribs of angle iron 6 inches deep, 3 inches wide and ½ inch thick; a similar angle iron reversed being riveted to each rib. These ribs are spaced two feet apart throughout the entire length. Extending across the bottom of the vessel at each rib are floor timbers 2 feet deep, formed of plate iron ½ inch thick, along the lower edge of which is riveted the angle iron ribs, and along the top edge of which is riveted the reversed angle iron. There are fore and aft keelsons made of plate iron, in box form, six inches deep, and fastened to top of floor timbers, upon which are placed ten horizontal fire tube boilers. These boilers are arranged five on each side, with a fire room amidships, common to both sides.

"*Engines.*—Immediately aft of the boilers are the main engines, eight in number, already in a nearly completed state. There are two propeller shafts, with four engines upon each, so arranged that each propeller is quite independent of the other. The engines are vertical, overhead beam, condensing engines, each cylinder being 45¾ inches diameter by 3½ feet stroke of piston.

"*Girders.*—In the rear of the boilers, attached to the sides of the ship, are strong plate iron beams running fore and aft, and about 14 feet from the bottom. To these are attached five plate iron girder frames, extending across the ship, and placed one immediately forward of the forward boilers, and the other four between each pair of boilers. These fore and aft beams and athwartship girder frames are very strong and well calculated to strengthen that part of the hull, besides being capable of supporting any superincumbent weight that may be brought upon them amidships. The engine frames are eight in number, formed of plate iron, each extending quite across the vessel, and firmly fastened to the sides near the bottom, and at a height of about 14 feet above it.

"It now remains to complete a small portion of the plating near the bow and the stern: put in the beams and the decks; attach a fore and aft box keelson to the floor timbers amidships, throughout the whole length of the vessel (30 x 18 inches); make the flue connections and chimney to the boilers; connect the engines, and add a few wanting pieces; put in floor plates to engine and fire rooms; make and attach the propeller shaft bearers to the outside of the vessel; supply the propellers; put in the required bulkheads; apply the armor, and the machinery for loading and working the guns; and to manufacture the guns themselves.

CHANGE OF PLAN.

"It is proper to state that the original projector of the vessel was the late Robert L. Stevens, and that his brother Edwin A. Stevens, who now proposes to complete it, has materially changed the plans from what appears to have been originally intended. Instead of the vertical sides above water, clothed with armor and pierced with gun ports, which seems to have been the design of Robert L. Stevens, the plans presented to us bear date of November, 1861, and resemble the inclined armor plated ships patented in England, with the inclined armor pierced with gun ports; whereas Mr. Stevens places his guns on top of the upper deck, depending upon their immense size for their own protection; . . . the training and loading of the guns to be accomplished by novel arrangements of steam machinery below the deck.

PLANS FOR COMPLETION.

"At 21 feet from the bottom, a deck, which forward and aft of the machinery will be bomb proof by having bottom layer of plate iron ½ inch thick, above this a layer of wood plank 6 inches thick, covered with layer of iron one inch thick. This deck is contained over the machinery, but of ordinary material and strength. Over latter part of this deck is constructed with inclined armor extending from three feet beyond the present side of the vessel to fourteen feet inboard, and seven feet high, giving an upper deck upon which the guns are to be placed, of twenty-three feet wide amidships. This inclined armor is formed of plate iron in seven laminæ, six of one inch, and seventh of ¾ inch, making 6¾ inches. Supporting this iron armor are iron beams 8 inches deep, filled in between with locust. Under these again are locust planks 6 inches thick, making in all 6¾ inches of iron and 14 inches of wood, placed at an angle of 27 deg. with the horizon. The forward and after ends of what may be termed the loading house, within this inclined armor, are inclosed with similar armor, inclined in a fore and aft direction, and it is forward and aft of this that the 21 feet deck is bomb proof. The flat deck uniting the upper edges of this inclined armor is 120 feet long, and is made bomb proof by having first a layer of plate iron ½ inch thick beneath the beams, beneath which is laid wooden planking six inches thick, which again receives two layers of iron ¾ inch thick. The side armor below the water line, extending throughout the entire length would be of iron two inches thick to a depth of two feet, and one inch thick for one foot further down, backed by solid oak three feet thick at the upper edge amidships; the thickness gradually lessening as it descends, until at six feet depth the iron side of the vessel proper is depended upon for its own protection.

"When the vessel prepares for action with the enemy, she is settled to a greater than ordinary draft by the admission to tanks of salt water, for partially submerging and giving better protection to the vessel.

"The armament proposed consists of five 15 inches Rodman guns, . . . and two 10 inches rifled guns. These are to be placed on the extreme upper deck, over the engines and boilers.

"She differs from the ordinary war vessels with which we are acquainted, first, in having long slender ends; second, in employing two independent propellers with several engines attached to each; third, in depending entirely upon a force blower for the ventilation of the lower part of the vessel when in action; fourth, in employing a heavier armament than has yet been put afloat, and training and loading these heavy guns by steam machinery below the deck, manipulated by persons who do not see the guns; fifth, in having the guns exposed to the direct fire of the enemy, upon the top of, instead of within an iron clad vessel; sixth, in settling the vessel when going into action, and in several other respects which will develop themselves in the course of this report.

Estimated total cost of vessel complete	$1,283,294
Of this amount there has been paid by the government.....	500,000
Leaving yet to be provided for..	$783,294

"Of this latter sum Mr. Stevens states that he has expended from his own resources, $228,435.87."

CONCLUSION.

After criticising the structure of the unfinished vessel, and the plans for its completion, the board conclude: "The most powerful battery, the highest speed, and the most thorough protection to any vessel yet produced; and our regrets that the plans of the vessel as presented to us would not, in our opinion, accomplish fully and completely the ends proposed." Some of the objections found by the board to the design of the vessel, was that her great length compared with the transverse strength, rendered her unsafe in a heavy sea, while for harbor service alone she would be inconvenient on account of her length and draft of water.

This naval board was composed of Commodore S. H. Stringham, Commander William Inman, Capt. Thomas A. Dornin, Albin A. Stimers, chief engineer, all of the U. S. navy, and Prof. Joseph Henry of Smithsonian Institution. It will be noted there was not a naval constructor of the U. S. navy on the board; but their experience had been wholly with wooden hull vessels. The only member, it is believed, who had any practical knowledge of the subject was the chief engineer. The Secretary of the Navy shortly after declined the offer for the completion of the vessel, and during the same year the government released all their interest in the vessel to Edwin A. Stevens by an act of Congress.

In 1868 steps were taken for the completion of the Stevens battery, and several radical changes were made from the former design. The hull of the vessel had an inner skin added up to the 14 feet water line, making the hull double skin to that point, with a space varying from 22½ inches on the bottom to 6½ inches at the top. There were seven transverse bulkheads. New engines and boilers were also built and erected on board. The armor as proposed, was 10 inches thick for four feet below the main deck, and thence five inches for about four feet. This was not put in place. The vessel itself as far as completed was given to the State of New Jersey in 1875, and subsequently sold on September 29, 1880, to W. E. Laimbeer, of New York, for $55,000 by the Court of Chancery of New Jersey, who broke up the vessel for the old metal. The iron used in the rebuilding of the vessel was rolled by the Abbott Rolling Mills; and the new machinery was constructed by the Delamater Iron Works of New York.

The construction of the Stevens battery was an object of much curiosity for many years, more so on account of its building being carried on under great secrecy, in an inclosed ship house, that was further protected from public scrutiny by a high board inclosure. The builders always refused to impart any information about the design, or progress made with the vessel—except when they thought it would contribute to their interests, by publication, or otherwise, and that was seldom done—to any of the engineering or mechanical journals of the day, or to the marine interests, for which there were good and sufficient reasons in the early stages of the work. It was locked up to the last. That was a privilege the contractor had, even though the U. S. government furnished the funds for building.

This project of an iron war vessel cost the Stevens brothers near a million dollars, it is thought, for which the State of New Jersey received about $66,000 at the sale of the effects in 1880. That was paying a high price to develop an idea on a subject that was so imperfectly understood at the time. There were too many problems at the time to be worked out to a successful issue for such a vessel. The investment of the U. S. government in the project was no doubt money well spent, as the construction of the vessel at first was one of the factors that kept the designers of our naval ordnance striving to keep in advance, with the improved gun, of the improved construction of the naval vessels. In that way alone, the money was well invested. The Navy Department expended from 1845 to 1855 more money than was appropriated for this battery as "experiments" on naval vessels, that never produced, even indirectly, any return except to the contractors and inventors.

It was at this period when a steam vessel having a ram bow, and the steam battering ram made their first appearance in actual service, and a short review of that instrument of warfare, in its earliest stages in this country, if not in the world, will be of interest.

(To be continued.)

To Oxidize a Watch Case.—First clean it thoroughly, then pass short brass wire through the ring to hold the case, which is not to be touched. The case is heated slightly over an alcohol lamp, being rubbed with ordinary wax, and allowed to cool. The wax is removed from the outside and inside with a linen rag, using a pointed piece of wood for the places not reached by the cloth. With too much wax the operation would not succeed, and spots would be formed. A handful of cotton threads soaked in benzine is placed on a piece of sheet iron and set on fire. The case is held over the flame for a minute or two, so as to cover it with a uniform layer of soot. On cooling it is cleaned with a piece of soft linen. Should the operation not be successful at first, it is to be repeated. It might be better to begin practice with a lady's watch case; small surfaces being more easily treated than those more extended.

CAUSE OF VITIATION OF CONFINED AIR.

HOW ILL EFFECTS ARE MODIFIED BY CONSTANT VENTILATION.

BY DR. ALFRED GRADENWITZ.

THE vitiation of confined air is dependent on a number of factors, some of which, such as an excess of carbonic acid, or hydrogen sulphide, are perfectly well known. Some other factors are, however, far from being elucidated. Products of respiration and perspiration may after some time have fatal effects on subjects living in confined air. These various substances are known by the name of *miasmata*, which however fails to convey any idea of their nature and properties. It has been shown that air which has been used for respiration is highly disagreeable, and liable, even after being freed from its carbonic acid and restored to its normal percentage of oxygen, to produce rather serious trouble, such as somnolence and nausea. Respiration thus alters the chemical composition of air. A French scientist, Dr. H. Henriet,* has recently investigated this change, and a short description of his researches is given in the following.

Air expired by the lungs contains in addition to oxygen, nitrogen, and carbonic acid, a quantity of water vapor. If this vapor is condensed, a colorless liquid with a slight flat smell, showing a neutral chemical reaction, is obtained. On being distilled together with a base it will give off a gas of strongly ammoniacal odor, being highly alkaline and very soluble in water. When heated with dilute sulphuric acid or some similar acid, it however gives off during distillation acid products, showing highly reductive properties. The condensed water coming from the lungs thus contains one or more salts with volatile acid and base.

If water condensed from expired air is dried above sulphuric acid, at ordinary temperature and pressure, a residue corresponding to about 7 grains per quart of water is obtained. This residue appears under the microscope to be entirely crystalline. If heated to 36 deg. C. (97 deg. F.) for 24 hours it will lose 21 per cent, and if maintained at 80 deg. (176 deg. F.) 45 per cent of its initial weight. After being heated to 80 deg. C. (176 deg. F.) certain crystals are found to have disappeared. If this residue is exposed to a gas flame, it assumes a slightly brownish color at some points, thus showing that it contains only quite slight amounts of non-volatile organic matter, the remainder being of mineral origin. Part of this remainder being soluble in water will give with silver nitrate a white precipitate insoluble in nitric acid and soluble in ammonia, thus showing evidence that this portion contains chlorides. The other portion, which is insoluble in water, is dissolved entirely in hydrochloric acid, and with ammonium oxalate gives a white precipitate of calcium oxalate.

From the above it is seen that the water vapor expired by the lungs contains solid matters, about half of which is made up of volatile ammonia salt, and the other half of salt due most likely to the liquids of the larynx and nasal cavities having been carried along. The ammonia salts will render the condensed water a kind of culture bouillon, in which various micro-organisms can be developed.

As soon as these products of respiration are given off into the air, the latter will be vitiated, owing to their reductive properties. Now it is interesting to note that there is some limit to the vitiation of air due to these products.

Dr. Henriet has shown, in fact, that another phenomenon, that of condensation of water vapor, is connected with this vitiation of the air. Water vapor on condensation carries along all soluble substances contained in the air, depositing them together with the liquid drops, while any insoluble gases are left. If, therefore, condensation is produced in a room, the vitiation of the air will remain practically constant, any addition of impurities resulting in equal amounts of the same substances being condensed.

If the temperature of the room is low, say 15 deg. C. (59 deg. F.) the amount of vapor required for saturating the air will be slight; and if this be supplied by respiration, the amount of expired substances will be small. If the amount of water vapor increases at constant temperature, condensation will be produced, and the walls of the room will become covered with small drops holding in solution the products of respiration. There is no increase in the vitiation of the air from this moment, only the number of precipitated water drops and the percentage of expired carbonic acid being increased.

In the case of higher temperatures, e. g., 26 deg. C. (79 deg. F.) a larger amount of vapor will be required for saturating the air and producing a limit of vitiation. It is thus seen that the vitiation of air in a closed room will be the greater as the temperature is higher, this increase in vitiation occurring at a more rapid rate as the temperature is higher, because the secretions of the skin then become far more abundant.

If a subject has stayed in a confined atmosphere long enough to produce condensation, a stream of small drops charged with dissolved impurities will be deposited on the walls and carpets of the room, and clothes of the persons staying in it. These drops may become real culture bouillons for a number of micro-organisms, and if after condensation the room be thoroughly ventilated the disagreeable odor due to the expired substances will be found to remain. This applies especially to sick-rooms, school-halls, hospitals, assembly halls, etc., which for a long time retain the odor.

In order to avoid the vitiation of closed rooms, condensation should be prevented by a constant ventilation. The Chamber of Deputies at Paris, in which the air is renewed constantly during the sittings, possesses no odor of its own, most likely because of the absence of any condensation. In dwelling rooms it would be sufficient to maintain all inside doors open, when a slight opening of a window would be sufficient to produce a permanent ventilation. This is especially desirable in bed-rooms, in which a half-opened window will be found the best means of maintaining the air at a normal condition.

The minimum temperature at which, owing to the moisture due to respiration, physical trouble may be produced is termed by Dr. Henriet "critical temperature of confined air." This temperature, which seems to be in the neighborhood of 25 deg. C. (77 deg. F.) should never be exceeded if it can be avoided. On the other hand, the hydroscopic state of the air should be kept as low as possible, in order to maintain hygienic conditions.

* Revue générale des Sciences, No. 12, 1907.

LATE EGYPTIAN EXCAVATION.

By A. M. LYTHGOE.

IN the report of the excavations undertaken by the museum expedition at the Pyramids of Lisht, given in the April Bulletin, the first stages in the clearing of the eastern side of the pyramid of Amenemhat I. were described. The work has continued without interruption during the last three months and has now resulted in the complete excavation of the pyramid temple and in the determination of the principal external features of the pyramid on this eastern side.

The method employed in the earlier stages of the work at the southeast angle of the pyramid, as outlined in the first report, has since been continued over the greater part of its entire eastern side—first, the removal of drift sand and the disintegrated limestone from the plundered core of the pyramid, thus exposing the house walls and similar construction which were found to represent a later occupation of the site; and finally, after recording completely these remains by means of plans and photographs, the continuation of the excavation down to the original twelfth dynasty construction underneath. Owing to the great mass of debris to be removed, a force of 250 workmen was employed during the month of March, and 150 have since continued the clearing of the lower levels during April and May.

Reference was made in the first report to tentative excavations on this part of the site by the French expedition ten years ago. These resulted in the partial uncovering of the remains of the temple at its easternmost end, and also of a mastabatomb of Antefaker, an important official of the twelfth dynasty, just south of the temple. Under the plan adopted in the present work—of clearing back completely to the face of the pyramid itself—important material and facts have now been recovered which make a distinct contribution to the history of Egyptian architecture and art during this period of the Middle Empire.

The pyramid temple of Amenemhat I. has been found to differ in its position from other similar temples, in that it stands on a lower level than the pyramid to which it was directly attached in its use. The rising slope of the hill on which this pyramid is built was met, in the first instance, by the construction of a platform along the eastern face of the pyramid, supported on its outer side by a retaining wall parallel with the pyramid face and of an average height of 2.50 meters. This platform is interrupted about the middle of its length by a recess, 36 meters wide, which is on a level with the base of the platform wall and cuts back into the bedrock of the hill to a perpendicular face of 2 meters at the rear end nearest the pyramid. On both its northern and southern sides the recess is flanked by a heavy wall of mud brick, which abuts on the rock cut face of the recess and runs eastward beyond the retaining wall of the platform, thus framing in the position of the temple. The latter, with its entrance on its eastern end overlooking the Nile Valley, has a total length of 31.60 meters, resting in the rear against the rock cut face of the recess.

As the excavation progressed it became clear that a reconstruction of the temple had taken place at some period subsequent to its erection, the evidence for this resting in part on the occurrence of limestone blocks bearing scenes in relief with the names of Amenemhat—and which were without question from the original construction of that kind—as reused material in the foundations, as they are now preserved, of the temple walls. The date at which this reconstruction took place can be more certainly fixed when the excavations have been carried further and have included the ground immediately east of the front of the temple, where indications point to the possibility of remains of an outer gateway. From this a long incline or footway can be plainly discerned from the present surface, leading down to the cultivated fields of the Nile Valley.

The excavation of the temple site has yielded, however, a very considerable amount of material from the original temple of Amenemhat, from which the main features of the structure can be determined. This includes many fragments and a number of complete blocks of painted relief from inscriptions and scenes on the temple walls. In one scene Amenemhat is represented as receiving the gift of life from the gods. All the relief is most delicately and beautifully modeled and in many cases has its color still freshly preserved. Blocks bearing inscriptions give the names of Amenemhat, and in one case those of Amenemhat and his son Usertesen I. jointly; from which it is certain either that the temple was constructed in part during the last ten years of Amenemhat's reign, when, as we know, Usertesen acted as co-regent with him, or that it was finished after Amenemhat's death by Usertesen, who then placed his own name on the temple walls with that of his father.

Interesting architectural material has been recovered also, such as fragments of the temple columns, of the so-called "Proto-Doric" style, bearing perpendicular lines of inscriptions on two opposite sides; ceiling blocks of the temple, with representations of the stars in painted relief; and two door jambs, each bearing in double columns of the same beautiful relief the names of Amenemhat.

It remained for the excavation of the rear end of the temple to result in the recovery of the two most important objects which it contained originally. These are the "false door" or offering stela of the temple—the place toward which the offerings were made to the king—and the great temple altar, or offering table.

The stela is of a fine grained limestone and is slightly broken away at the top, its present measurements being 1.28 meters in height, 1.25 meters in width and 50 centimeters in thickness. It has on its eight panels perpendicular lines of inscription giving the various titles and names of Amenemhat, and, as the only example of a royal stela of its kind which has yet been found, it is an object of unique importance.

The altar is of red granite, and is 1.66 meters in length, 1.62 meters in width and 1.30 meters in height. The lower part, which originally sat below the level of the temple pavement, is only roughly blocked out, but above this its four sides are worked to a finish surface 50 centimeters wide. At the back it is uninscribed, but on its other three sides it has a procession of figures, in sunken relief, representing the various *nomes*, or provinces, of Egypt. These advance from either side toward the center of the front, where the *cartouche* of the king is inscribed, each figure bearing in its hands an offering. The top of the altar is worked out at the front into a rectangular offering basin, and at the back has a representation of offerings—two vases and the conventional loaf, the latter inscribed with the king's name.

Both the stela and the altar were found, not in their original positions in the rear end of the temple, but at a point to which they had been moved just outside its northern wall—at the western end of the open passage between this wall and the mud brick wall referred to above, which bounds the temple site on this side. From the manner in which both objects had been placed there—carefully propped up with small blocks beneath them—it is clear that their removal from the temple took place at a time when their significance was still known, possibly at the time of the reconstruction of the temple.

While this excavation of the pyramid temple has

been in progress, work has been carried on simultaneously for the last three months on the cemetery west of the pyramid. As was to be supposed from the proximity of the cemetery to the royal tent of Amenemhat, its tombs are proving to be of important twelfth dynasty types, both in their construction and in the character of their contents, and their excavation has been an important factor in the satisfactory results of the year.

All the work of excavation is now being brought to an end for the present season, and in early July, when its results have been finally recorded, the expedition will withdraw from Egypt for the remainder of the summer.—From the Bulletin of the Metropolitan Museum of Art.

ENGINEERING NOTES.

The plan suggested by Secretary Taft, and approved by President Roosevelt, for the reorganization of the administrative methods of the Panama Canal Commission became operative on August 15. According to this plan, the office of the secretary of the Commission will be transferred from Washington to the Isthmus, where much of its work will be transacted. The plan also provides for the office of examiner of accounts and a disbursing officer on the Isthmus; with assistant examiner and a disbursing officer in Washington.

A new concrete building at the plant of Bridgman Brothers, manufacturers of steam fitters' supplies, in Philadelphia, collapsed on July 10, killing three men outright and fatally injuring others. The building, located at Fifteenth Street and Washington Avenue, was four stories high and was just being put under roof, when a section 30 feet in width and extending the entire height of the structure, fell outward. About 30 men were at work on the side which gave way, and they were carried down in the debris. It is currently reported that the cause of the accident was the premature removal of the forms.

Sir Oliver Lodge, the distinguished British scientist, has for some years past been engaged in the smoke prevention problem, and has recently carried out a series of experiments in the direction of heating boilers with ordinary coal without any smoke emission whatever. His method is to be tested in a practical manner at a power station near Birmingham, one set of furnaces to be equipped on his lines and working beside another similar set of furnaces, both using the same fuel and stoking, so that definite comparative data can be secured respecting the advantages of his process. The main feature of his principle comprises the passing of the flame along an inner tube of fireclay, where the process of combustion can be completed owing to the walls being red hot. These walls radiate heat to the boiler, the arrangement being such that the flames do not come into contact with the boiler at all. By this means smoke will, it is hoped, be eliminated, the conditions being favorable to complete combustion.

Two mammoth liners for the Hamburg-American and the International Mercantile Marine companies, respectively, are to be constructed at the Belfast shipyards of Messrs. Harland & Wolff. That for the former company will be 760 feet in length, and will exceed the new Cunard turbine vessels in tonnage, while that for the second company is to be even larger. In respect to this increase in the size of vessels, Lord Pirrie, the head of the Belfast firm, recently delivered an interesting paper in which he emphasized the fact that progressive development in the size of ocean vessels was at present being severely restricted by the lack of facilities in entering the requisite ports to which such vessels must necessarily sail, and urged the various harbor authorities to greater enterprise in the provision of deep and wide navigation channels. The above two ships will not be laid down for a few months, since the nine slips in the yards are already occupied and have been booked for other projected vessels, which will keep the yards working at full capacity for some time to come.

An important railroad construction scheme which will be of far-reaching importance in the development of Peru is being projected in London, the requisite concession having been granted to a well-known British engineer. It is proposed to build a railroad from Port Payta on the Pacific coast to Port Limon, west of Iquitos, on the Amazon, which is the head of steam navigation on that river. Such a railroad would be 400 miles in length and the route would cross the Andes at the one gap in the range at an altitude of 6,600 feet. The total cost of the scheme will approximate $12,500,000, and the Peruvian government is prepared to guarantee interest upon the capital bonds. By the opening up of such a route a great impetus would be imparted to the agricultural and mining interests of the country, since the railroad would extend through the rich India-rubber forests, cereal-raising country, and the gold, copper, silver, and coal mines in the interior of the country. At the present time there is no communication between eastern and western Peru except by mule pack, and the lack of transportation facilities has appreciably retarded the development of the interior districts of the country.

SCIENCE NOTES.

Mr. A. E. Taylor's successful experiments on the synthesis of protein, an account of which is given in a recent issue of the "Publications of the University of California," are of the greatest interest to the chemist and the biologist. Attention has frequently been called in these columns to the chemical changes brought about through the agency of ferments, or enzymes, as they are now more suitably termed. For instance, starch is acted upon by water in the presence of the diastase of the saliva or of malted barley, yielding simpler products (maltose, dextrins, etc.); while white of egg, which may be taken as a typical protein, is transformed into simpler products (peptones, amino-acids, etc.), through the agency of the pepsin of the stomach and trypsin of the pancreas. These reactions can also be brought about outside the body by digesting the substances with water, at a suitable temperature and in the presence of minute quantities of the enzymes. Now it has been found that if the action of certain enzymes be allowed to continue after the breaking down (hydrolysis) of the original substance has proceeded as far as it will, a reversed action may take place under suitable conditions, and the products be then gradually condensed again to form the original product. This has been established in the case of the enzymes that act upon starch and fat, but hitherto all attempts to effect a similar synthesis of proteins have been fruitless. Mr. Taylor, attributing these failures mainly to the insufficient stability of the enzyme preparations employed, made experiments with trypsin from different sources, and found that that contained in the liver of the large soft-shelled clam did not lose its activity during a long period. The protein used in the experiments was protamine sulphate, obtained from the spermatozoa of the striped bass; it was chosen as being one of the simplest bodies of the kind, and yielding but few products on treatment with trypsin. The digestion was first carried on in a flask, as far as it would go, and the solution of the products (mainly compound ammonias) sealed up in another flask with a glycerine extract of the liver of the clam. The contents of the flask gradually became turbid, and finally, after some months, there collected at the bottom a white deposit which was found to correspond in composition and properties with the original protein. This is the first experimental proof of the commonly accepted theory that the formation of proteins in plants and in the absorption of the products of digestion in animals are both processes of condensation, brought about by the influence of enzymes, which are themselves unaffected in the reaction.

The Observatory at Perth (western Australia) has just issued its first volume, a catalogue of 420 standard stars. In an accompanying letter Mr. W. Ernest Cooke, the government astronomer for west Australia, describes the work done, and outlines the future policy of the observatory staff. They have undertaken the zone 32 deg. to 40 deg. south declination for the International Photo Durchmusterung. Nearly all the necessary photographs (for the catalogue portion) have been taken, but the measurement is only now being commenced. In all probability they will not be able to take the long exposure photographs for mechanical reproduction. In order to obtain the plate constants three stars have been selected, where practicable, in every square degree, and these are being observed with the transit circle. This work was commenced on October 6, 1901. Each observation consists of transits over seven vertical wires and readings of four microscopes. The instrument is a modern one by Messrs. Troughton & Simms, having a clear aperture of six inches. The "seeing" is usually good and the definition excellent. The old method, which was first adopted, of determining clock error from equatorial stars of the Nautical Almanac, and the nadir point from reflections over the mercury trough, was not considered satisfactory and was definitely abandoned on July 28, 1905, after zones 32 deg., 33 deg., 39 deg., and 40 deg., and part of 33 to 34 deg. had been completed. It was then determined to obtain both clock error and equator point from standard stars situated within, or close to the zone of observation. Auwers's "Fundamental Catalog für Zonenbeobachtungen am Südhimmel" was accepted as the basis of the system, but since at least three reference stars per hour are required for each zone of 2 deg. it was necessary to choose a number of stars to act as secondary standards, and to observe these a considerable number of times. This has been done and the present catalogue is the result. It will be adopted as fundamental in the zone reductions until the whole zone of 31 deg. to 41 deg. is completed; and the results previously obtained between October 6, 1901, and July 28, 1905, will be reduced as well as possible to the present system. In a few years a satisfactory determination (three complete observations) of the positions of some eight to ten thousand stars fairly well distributed over the region 31 deg. to 41 deg. will be obtained, and these will be used for the determination of the plate constants in the astrographic catalogue. And now a few words as to the future of transit work. I have adopted a plan which I hope to see copied by a number of other observatories. I propose that the Perth Observatory shall confine its transit observations to this particular region and prepare a catalogue of exactly the same stars every ten or twelve years, or as frequently as possible, including each time a redetermination of the 420 secondary standards. Thus in course of time the worker in this part of the sky will turn to the Perth catalogues with the certainty of finding a number of stars in any ordinary sized field, all of whose positions have been regularly determined from time to time and can therefore be brought reliably up to date. Notwithstanding the millions of observations which have been taken and the hundreds of existing catalogues there are very few parts of the sky in which the above condition exists. It is hoped that this attempt to place meridian work upon a more satisfactory basis may be followed by others, so that the output of energy may be concentrated upon some systematic measuring of the sky instead of being squandered as it has to some extent been in the past. In particular Mr. Cooke hopes that when their present programme is finished the four Australian observatories will co-operate in order to maintain a systematic survey of the region 20 deg. to 60 deg. south declination.

TRADE NOTES AND FORMULÆ.

A Glue for Attaching Ebonite to Metal is made by boiling Cologne glue and mixing with fine clean ashes to form a homogeneous paste. Use the paste warm. While drying, it is advisable to press the pieces together, taking care that they are well adjusted.

Ready Method for Perforating Iron.—An easy and curious method for making holes in iron bars or forged plates consists in molding a stick of sulphur in the form of the hole desired. The iron is heated to the white, and the sulphur pressed on the spot for the hole. It will enter as into butter, and the hole will have the size and form of the stick of sulphur.

To Remove Rust Spots from Burnished Steel.—Olive oil is poured in the spots and allowed to remain several days. A rubbing is given afterward with emery or tripoli without wiping off the oil, which is always to be brought back on the spots. The emery and oil are removed with a rag. Another rubbing is given with emery wet with vinegar, and finally with fine plumbago, using a chamois skin.

To Give a Punch a Very Hard Temper.—Heat it to white red and place it quickly on sealing wax, leave it for a second only and move it to another place; and so on, until the punch will not melt the wax. For use, dip it in oil of turpentine. A still higher degree of hardness can be secured by quenching the tool, heated to the white, in quicksilver. Thus prepared, the tool will perforate holes in rock crystal, as easily as in wood.

Tempering of Small Drills.—The best way of tempering the small drills used by clockmakers in the perforation of pinions, arbors, etc., is the air method; that is, after the drill is prepared and brought to a red heat bordering on the white, it should be withdrawn from the flame by a back and forth movement, subjecting it alternately to the action of the heat and of the air. By this process drills become very hard and are not warped.

Tempering of Aluminium.—Aluminium hardens under the tempering produced by prolonged rolling, forging, stamping, or stretching. But the tempering effect is much more noticeable, when the metal is brought to red heat and suddenly quenched in water. When combined with titanium, aluminium is capable of undergoing double tempering. This operation consists in bringing the metal to a given degree of heat and quenching suddenly in ice water containing glycerine; it is then reheated to a temperature less than the previous and quenched again in ice water.

TABLE OF CONTENTS.

PAGE

I. ARCHÆOLOGY.—Late Egyptian Excavation.—By A. M. LYTHGOE 207

II. ASTRONOMY.—Recent Progress in Astronomy.—By Prof. KLEIN.—18 illustrations 200

III. CHEMISTRY.—Potassium Chloroplatinite for Photographic Use.—By RUDOLPH BOLLING 199
Cause of Vitiation of Confined Air.—By Dr. ALFRED GRADENWITZ 207

IV. ELECTRICITY.—Elements of Electrical Engineering.—By A. E. WATSON, E.E., Ph.D.—3 illustrations 197
Automatic Speed Control for Magneto.—3 illustrations 198

V. ENGINEERING.—The Kafue River Bridge on the Cape to Cairo Railroad.—By the English Correspondent of the SCIENTIFIC AMERICAN.—3 illustrations 204
Engineering Notes 208

VI. HOROLOGY.—Note on the Gridiron Pendulum.—By C. F. ADAMS.—1 illustration 199

VII. MINERALOGY.—Asbestos.—By J. S. DILLER 195
About Meerschaum 195
The Commercial Uses of Fluorspar.—By ERNEST E. BURCHARD 199

VIII. MISCELLANEOUS.—Trade Notes and Formulæ 209
Science Notes 208

IX. NAVAL ARCHITECTURE.—The Development of Armored War Vessels.—V.—By J. H. MORRISON.—3 illustrations 205

X. TECHNOLOGY.—Turpentine from Waste Wood.—By J. E. TEEPLE, Ph.D. 194
Copper Mirrors.—By F. D. CHATTAWAY 195
The Spark Method for Grading Steels.—By ALBERT F. SHORE, M.E.—7 illustrations 206